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for the drilling-producing-pipe line industry

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for the refining-natural gasoline industry

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WORLD OIL

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OF COLLEGES AND CASING

WE WERE talking with a member of the faculty of a great Southwestern university a few days ago and he said something rather startling. After a general discussion of some of the problems of the oil industry, he called to our attention some research he had done recently involving references to petroleum in books used in college curriculums.

"I found three, the index of which contained mention of petroleum," he said, "and of the three references, two had to do with oil scandals. Is it any wonder that our schools are turning out graduates who contribute to an unfriendly atmosphere for the oil industry when they come from their colleges with so little knowledge of the oil business?

"What has been the effect of the petroleum industry, for instance, on the economic aspects of the states of the Southwest? What has the oil industry meant to the citizens of the states from a standpoint of bettering their individual situations? What has the oil industry meant to these states (one need not limit the inquiry merely to the Southwest) from a standpoint of tax money, from the standpoint of schools?

"What a marvelous subject for a thesis would be involved in such a study on Oklahoma, or Texas, or even small parts of either. The information developed should be of interest to all the citizens of these states, and I think that a faithful portrayal of the actual facts would be of substantial benefit to the oil industry itself."

My visitor then pointed out that oil companies have been making grants for scholarships in geology and engineering—that there are few schools, having such courses which have not had the benefit of such scholarships, with the awarding of the scholarships strictly in the hands of the schools themselves.

"Why not award some scholarships to the students in the social sciences, for example, economics and history?" my visitor asked.

And we in turn echo, why not?

THE ACTION of a representative from Massachusetts in proposing a bill in the Congress which would apply a measure of government control on oil has raised strenuous objection on the part of the many oil men, and justly so. But we suspect that what the gentleman from Massachusetts desired most of all was more burning oil for his constituents, rather than to see his bill passed! But the problem of taking care of unprecedented demands for petroleum products is a real one, and one which the industry cannot allow to drift along without a concerted effort to solve.

Much of our trouble, most of it at present, gets back to pipe—to steel. The refineries are stepping up their expansion programs, but delivery of some products made of steel is holding up construction. WORLD OIL editors think that the capacity of the country will have to be increased about ¾ million barrels a day over what it was last year, if we meet the demands of year after next. They think that this is a minimum figure. It is somewhat more than API indicates as the program of the industry.

Pipe for pipe lines is another important consideration. Steel for tankers is another. But topping the list, from the standpoint of peacetime demand and wartime urgency, is casing.

No meeting of interested parties will likely result in the increase of casing tonnage, but maladjustment of supply can be helped by proper cooperation. Threat of anti-trust action no doubt has caused many companies to be fearful of an industry-wide and industry conducted plan for casing allocation, but there are signs that something will be done about it. We sincerely hope so because the oil industry will be the target of more legislation unless the people of this country are provided with necessary petroleum fuels.

Ray L. Dudley

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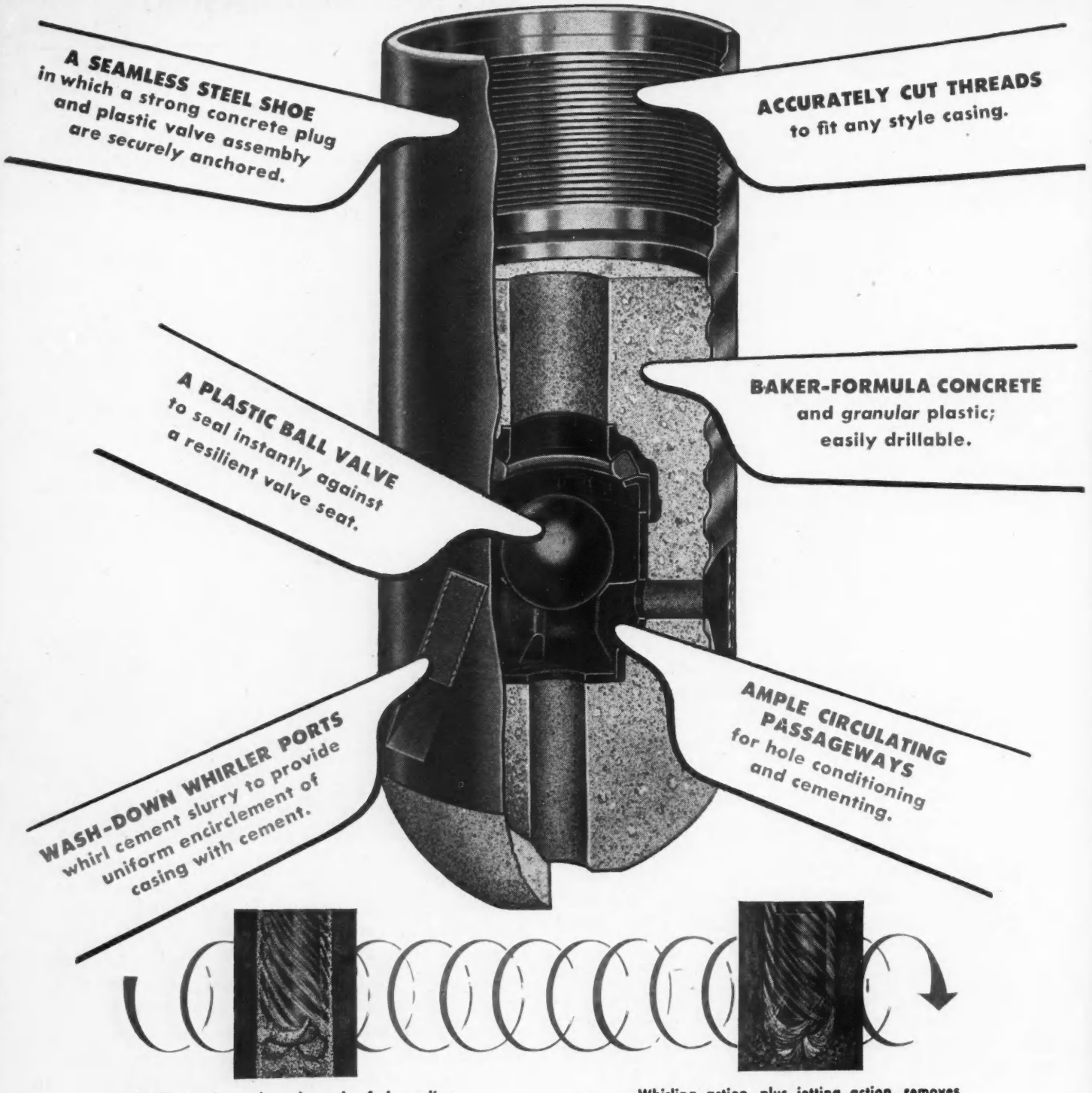
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The Changing Panorama

Coming: Scrap Steel from Europe

MOST PRECIOUS privilege of a free people is to raise their voices against government leaders when it becomes necessary.

Of late it has been too often necessary to exercise this privilege in the U. S., and too often the net result has been nothing more than a healthy workout for our vocal chords.

An exception, apparently, is the case of sorely-needed scrap steel. Months ago it was pointed out by the industry and by manufacturers that a senseless clause in the Marshall Plan calls for the shipment of scrap from scrap-hungry U. S. to scrap-glutted Europe. In December, the question was asked on this page of WORLD OIL: "Why not bring a lot of this scrap (in Europe) back to the U. S.?"

In January, this question appeared on WORLD OIL's publishers page: "Why in the name of common sense can't we get this scrap back?"

Last month from Washington came a gratifying answer. A program for bringing German iron and steel scrap to the U. S. was proposed by a special scrap mission sent to Germany by Secretary of Commerce Harriman. The mission recommended that an Anglo-American corporation be set up to operate a central scrap purchasing agency in bizonal Germany. The report said there are in Germany "huge tonnages of scrap surplus to German needs" which should be made available for export to U. S. scrap consumers."

Never mind that six experts had to bump their learned heads against a mountain of scrap before the government came awake to a fact long known by the industry and the equipment makers. The point is, the U. S. has at last officially discovered a source of needed scrap.

Unitization Makes Some New Friends

OWNERS of oil and gas royalties, who heretofore have been bitter opponents of unitized operations of oil fields, are beginning to understand the advantages to be gained from good operating and conservation practices. This significant trend was recently exemplified during a hearing on the unit operation of the Gibson sand zone in the West Antioch field of Garvin County, Oklahome. During the hearing, engineers and land owners were in complete accord and unanimous in their desire for a Corporation Commission order authorizing the unit operation. This was certainly in striking contrast to the knock down and drag out fight which developed when unitization for West Edmond's 30,000 acres was recommended by the engineers.

Engineers have learned an important lesson. Before applying for the West Antioch unit order, engineers for the various oil companies involved in the field, held a series of conferences to which all land and royalty owners were invited. The latter were advised to hire a good lawyer and have him check into the legal phases of the contract which was being prepared. As a result of this frank discussion, the engineers were able to convince the land owners that it was to their best interest to support the unit operation plan.

It is suggested that where similar plans are proposed, engineers and land owners get together in advance of the hearing, settle all outstanding points, and then present a united front before the regulatory body. In this way the cause of unitization can best be served.

Steel Men Defend Price Mark-ups

ALTHOUGH the steel industry has been widely criticized for recent increases in prices of some of its products, spokesmen for that industry stoutly defend the mark-ups. The adjustments were on products which had been unprofitable, they declared, and unprofitable operation by steel companies are not a good thing for anybody concerned. Profitable operations were said to be especially necessary at this time, when steel companies need to expand facilities and need adequate prices and earnings in order to raise the required capital.

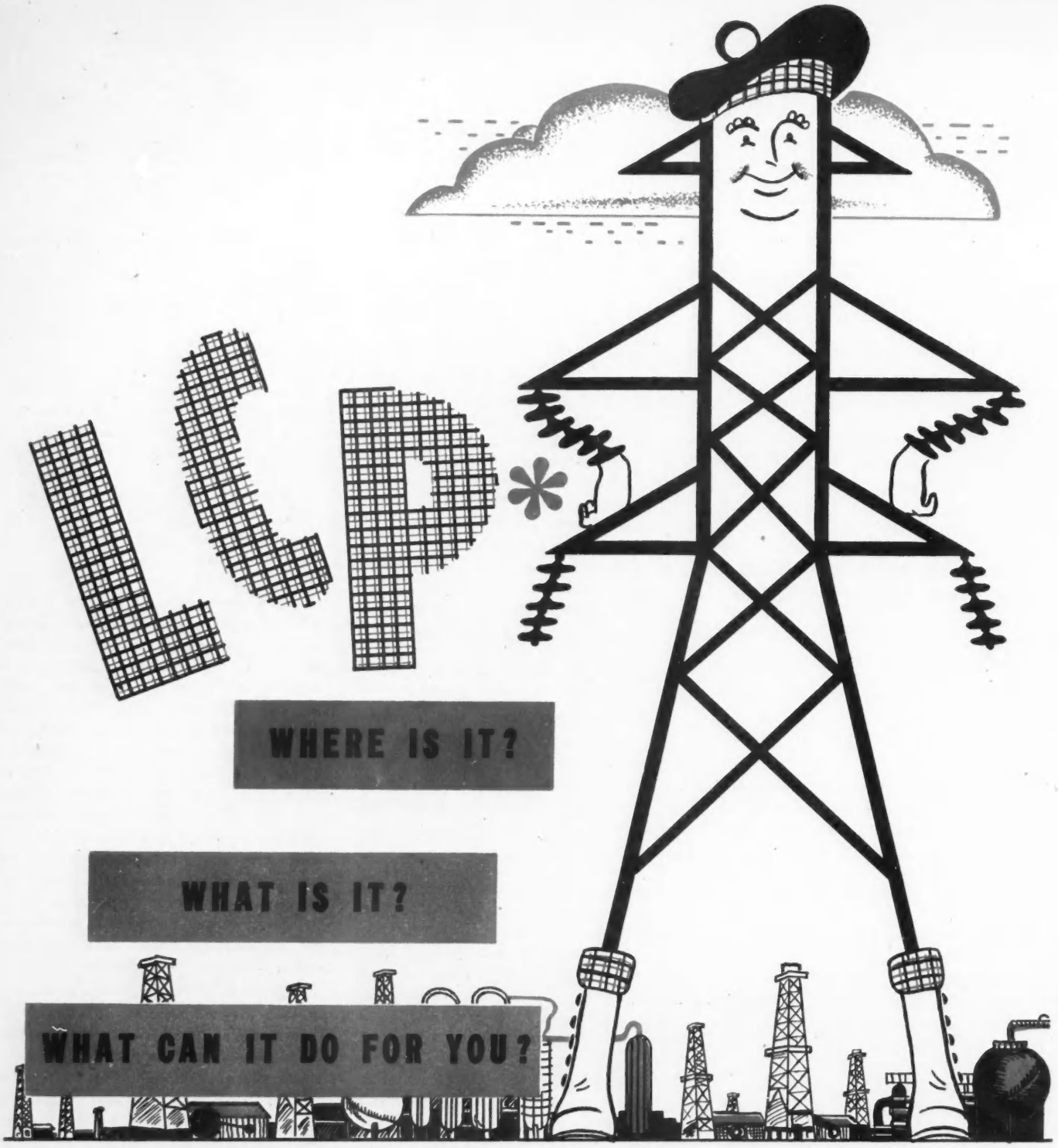
There are loud cries for enlarged facilities, but they cost heavily today, and because of high taxes, amounts left for reinvestment, from earnings, have been relatively small. In absence of favorable prices and earnings, the steel people say, the pattern of expansion has to be cut to suit the cloth of limited available expansion funds. The only other way would be to go heavily into debt by borrowing money or to try to sell stock, and either of those courses would be difficult in the face of unsatisfactory steel industry earnings.

During the eight years ending with 1947, the wholesale price of all commodities rose 108 percent, but the composite base price of steel, acording to the *Iron Age* index, advanced only 39 percent, with the industry repeatedly raising wages and salaries and with its costs for materials, supplies, and services rising.

Industry should be encouraged to operate on a profitable basis, the steel men emphasize, and should be stimulated by a wise tax policy permitting accumulation of adequate funds for rehabilitation and expansion at current costs.

The petroleum industry can vouch for the fact that expansion of facilities at present high costs makes favorable prices and earnings imperative. In each of the years 1947 and 1948, petroleum industry modernization and expansion are requiring more funds than the industry can generate from its own operations, in spite of relatively good prices and earnings, and it has been necessary to raise additional funds by issuing some new stock and doing substantial borrowing.

As an important user of steel mill products, which has been considerably handicapped by shortages of steel, the petroleum industry has a direct interest in the adequacy of steel mill facilities. Consequently, when steel companies assert that adjustments in prices of steel products are necessary to help them expand their facilities, they make a strong bid for the sympathy of the petroleum industry.



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MONTHLY NEWS ANALYSIS

MIDDLE EAST OIL TROUBLES U. S. . . . LATIN AMERICANS URGED TO ACTION
HIGH PROFITS FICTITIOUS . . . FUEL OIL STOCKS REDUCED TO MINIMUM
GASOLINE SCARCITY IMPENDS . . . INDUSTRY DEMANDS DESERVED CREDIT

Serious Problems Met in Middle East Development

While American oil companies are taking a prominent role in world oil developments, the U. S. as a nation similarly is now a dominant force in world affairs. These are facts not yet fully realized by the American people but quite real, and this leadership currently is posing for the nation a multitude of responsibilities and problems.

One of the most urgent and vital problems faced by the nation as a leader in global affairs is the problem of making the world's petroleum resources available for the peoples of the world.

In seeking to solve this problem, the government and the American petroleum industry have recognized that success depends on making available for increased use the rich oil resources of the Middle East, the Caribbean, and other areas.

In pursuance of this objective, Americans have now come up against some serious complications as regards the Middle East, and the whole national policy toward Middle East oil is under scrutiny. At the same time, emphasis is being placed upon the necessity of adequate oil reserves and oil industry facilities in the Western Hemisphere for meeting the New World's requirements.

With Russia making a strong bid for power in Italy and threatening to move troops into Iran, members of the U. S. Congress in the latter part of March were asking military men whether Middle East oil fields could be successfully defended in the event of a conflict with Russia. Answers were noncommittal. Also complicating Middle East development was the question of the partitioning of Palestine, originally approved but recently disapproved by the U. S. Whether the reversal of U. S. position would facilitate Middle East pipe line building by dissipating anti-American feeling among the Arabic countries remained to be seen.

The Palestine problem, however, was at least temporarily overshadowed by Russian expansion and the growing threat of eventual conflict with that nation. Urgently needing steel for many purposes, the U. S. in late March was carefully reconsidering the advisability of going ahead with shipment of large tonnages of steel to the Middle East for building pipe lines to the Mediterranean. Question arose as to whether work should be continued on the Trans-Arabian pipe line, in view of developments in Italy, Iran, Palestine, and elsewhere on the troubled international scene.

The U. S. government indicated that it might withdraw approval and support of the "Tapline," and ask that the steel be diverted to construction of tankers. It was indicated that pipe already delivered in the Middle East for the line to the Mediterranean might be used instead for delivering crude down to the Persian Gulf. As in the past, it was stated, the Persian Gulf might have to continue to serve as the tidewater outlet for Middle East oil, instead of building pipe lines to terminals on the Mediterranean. Men high in the government also pointed out that U. S. policy had to consider not only the advisability and hazards of putting large amounts of scarce steel into pipe lines across the Middle East but also the greater problem of the continued availability of Middle East oil.

Latin Americans Urged to Develop Oil with U. S. Aid

While studying the problems of development of oil in the Middle East, the U. S. government also is actively promoting an intensification of development of oil resources of the Western Hemisphere, especially in the Latin-American countries. In effect, the U. S. has officially proposed to 20 Latin-American countries, including Mexico, that they help to assure adequate oil for themselves and the Western Hemisphere by opening their doors to U. S. capital and U. S. technical knowledge and experience. A memorandum sent by the Department of State to each of these countries called attention to probability of oil being in short supply for the next few years at least, warned that the U. S. would not have exportable supplies, and suggested that the best insurance of supply for each country was development of its own resources.

After pointing out the desirability of self-sufficiency in oil for as many as possible of the countries of the Western Hemisphere, the memorandum suggested that these countries could materially stimulate oil development within their borders by enacting laws and regulations that would permit development by outside capital on reasonable and fair basis.

"The development of petroleum resources of any country with large potential oil areas requires vast amounts of capital, efficient management, and large numbers of highly trained technical and scientific personnel," stated the memorandum. "It is doubtful whether any one company or entity, no matter how large, could be expected to develop such resources successfully and efficiently. What is required is access to the best petroleum technology, great diversity of effort, and access to adequate and large volumes of risk capital, all of which would be available fully and freely by calling upon the world petroleum industry."

Following the dispatch of this memorandum, expressing U. S. views on the subject, it was believed that some Latin-American country would bring the matter up for open discussion at the Inter-American economic conference at Bogota on March 30. Under the assumption that the subject would be brought up, the delegation with Secretary of State Marshall at Bogota included personnel qualified to discuss it. The delegation included William J. Donnelly, ambassador to Venezuela, Secretaries Harriman and Synder, and a large staff of technical assistants, among them seveal from the military who have been extensively briefed on oil.

Real Profits in Form of Buying Power Not High

In common with most other industries, oil companies are reporting for 1947 comparatively high earnings or profits—high by former standards. Consequently, oil company executives are

having much to say about current reported profits to stockholders, employes, and the public. They are warning everybody concerned that all is not gold that glitters in the financial reports; that in view of present-day inflation, the reported profits are to an important extent fictitious.

Currently reported profits are misleading and more attractive in appearance than they actually are because accounting for tax purposes does not permit sufficient deductions from income for replacing wornout equipment and used-up raw materials when needed under present sharply higher costs of everything. Net income would be much lower if charges against it for replacement of wearing out facilities were fully in line with the high costs now encountered.

Although reported earnings are relatively high, they will not be in the aggregate quite enough in 1947 and 1948 to provide the capital required by the industry to maintain and replace crude oil and natural gas reserves, plants, and equipment at current costs, which are 50 to 200 percent higher than they were prewar. The industry had to issue new stock and borrow money in 1947 to continue in business on a basis demanded by the public, as it had much accumulated repair and modernization work to do besides trying to expand facilities. Likewise, the industry is spending more than $2 billion in 1948 for replacement, modernization, and expansion, and in doing so, it will have to raise at least $100 million from sources other than earnings, it has been estimated. Most of this is expected to be raised by borrowing from banks. If earnings were lower, borrowing would have to be heavier and could easily become difficult or impossible.

"Present tax laws do not recognize setting aside money at a rate fast enough to replace wornout equipment at present high costs," K. S. Adams, president of Phillips Petroleum Company, said in a company publication. A refinery which cost $5 million to build in 1928 is depreciated on the books at $250,000 per year, he said, on the assumption that its replacement cost at the end of 20 years will be no more than its original cost. But $15 million is needed to build that refinery today. Costs have gone up and funds set aside for the replacement are short by $10 million. The reported profits simply have to be relatively high to make up for such shortages and get the new plants needed to stay in business. (Incidentally, prices of oils also have to be relatively high to provide these necessary high reported profits, after also buying supplies and raw materials at present high costs, paying present high rates for labor, and distributing enough in cash dividends to keep stockholders interested in leaving their investment in the industry.)

Stocks Cut to Minimum In Meeting Fuel Demand

The industry has squeezed by in meeting demand for fuel oils. At the middle of March there was a tapering off in distress calls from consumers in the Eastern states, and it appeared that there would be no serious trouble in meeting requirements in the closing weeks of the heating season.

In getting by, it was necessary to drawn down stocks of distillate fuel oil and kerosine to virtually the lowest levels possible, especially on the East Coast and the Gulf Coast, which supplies the East Coast market in large part.

As of March 6 this year U. S. stocks of gas oil and distillate fuel oil totaled only 32,749,000 barrels, compared with 36,601,000 on March 8, 1947. Stocks were lower than a year ago on the East Coast, the Gulf Coast, and in North Louisiana-Arkansas, but were higher than a year ago in most other districts, including the Middle West.

U. S. kerosine stocks of 9,843,000 barrels March 6, 1948, compared with 10,816,000 barrels a year previously, with the East Coast and Gulf Coast responsible for the decrease.

Much of Reported Profit Is Profit Only in Name

The same situation as in refining exists in the producing and other phases of the industry. Companies are taking much of their oil from wells drilled in the past only $20,000 to $50,000 per well. Today, similar wells cost from $50,000 to $200,000 each. As a company charges a $50,000 well against earnings over the years, it must replace that well with one that may cost at least $150,000. The rate at which the company has been setting money aside for this purpose has been too low. This results in the publishing of earnings figures which are higher than otherwise would be true.

The tax laws and the company's books did not anticipate higher costs, and the company was not putting enough money aside to replace the refinery or the oil well. If companies could show present depreciation charges at rates high enough to enable them to rebuild and expand their plants at present costs, their reports would not show what appear to be high profits. Actually, a large part of these "bookkeeping profits" have to go back into the business to keep the companies going and to thus enable them to keep the consumers supplied with oils. Much of the reported profit is profit in name only. Actually, much of it belongs back in the "expense of doing business" side of the ledger.

In an address before the North Texas Oil and Gas Association at Wichita Falls, Texas, B. B. Jennings, president of Socony-Vacuum Oil Company, commented on the matter of under-depreciation, with the dollar now worth less than two-thirds of what it was prewar. He assumed a typical oil company performance in which a hypothetical company reported earnings for 1941 of $5 million after depreciation and depletion reserves of $5 million. For 1947, he said, that same company would probably have reported earnings of $9 million, again after reserves of $5 million. If, because new plants cost half again as much as old, actual depreciation is two-thirds of what is necessary, then 1947 reserves ought to be $7½ million instead of $5 million. Because the Internal Revenue Bureau will not allow, for tax purposes, extra depreciation as a charge against earnings, all of this will affect reported earnings and so make them $6½ million rather than $9 million, as reported by conventional accounting. The result to the imaginary stockholders would be pretty tough, added Jennings. In 1941, they had $5 million profit in 1941 dollars. For 1947, they got $6½ million, but in dollars worth about two-thirds as much, so that they netted the equivalent of only about $4,300,000 in 1941 money.

Gasoline Saving Needed To Prevent Shortage

Although the industry succeeded in avoiding serious shortages of fuel oils the past winter, with the cooperation of the public in conserving supplies, there lies ahead another threat of shortages. Gasoline supplies will be relatively scarce this spring and summer. It is hoped that supplies will be adequate through early summer, but in the latter part of the motoring season, scarcities will become more acute, and serious temporary shortages could arise, locally, especially in the Midwest and possibly the Eastern states.

In view of these possibilities, some petroleum economists and oil company executives are urging that the industry impress upon the public the need for conservative use of gasoline and elimination of unnecessary or wasteful usage. During the past fall and winter, oil companies and oil industry associations repeatedly urged the public to hold heating oil use to lowest levels possible, to help balance demand with supply and thus to help avoid serious shortages. At the same time, the industry was doing virtually everything possible to increase supply to maximum levels. With industry-public cooperation, there was suc-

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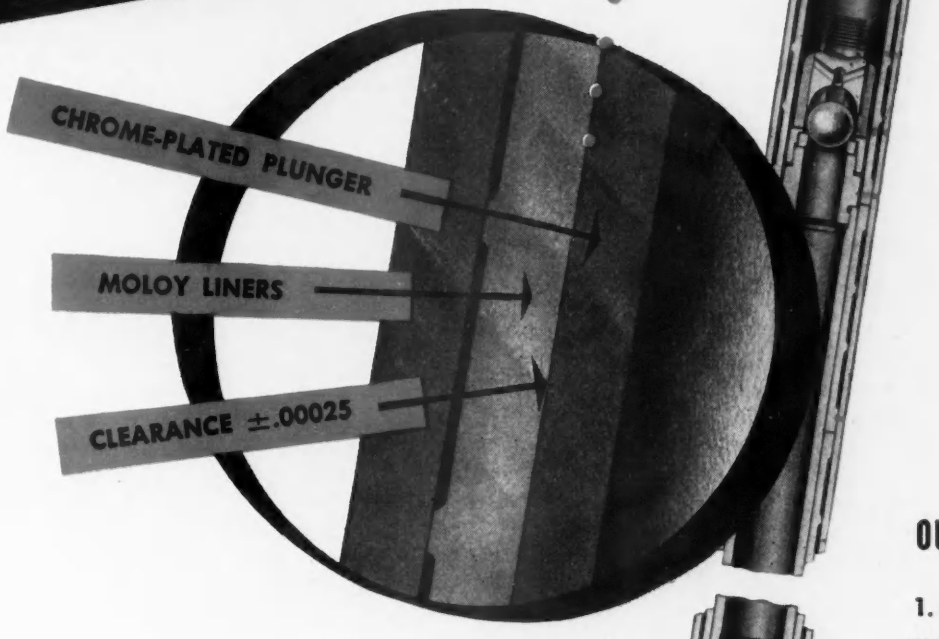

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cess in avoiding serious shortages. Similar cooperation in maximizing supply and minimizing demand should likewise make it possible to get through the heavy gasoline consuming season without serious shortages.

However, action toward conserving gasoline should be taken at once. Although gasoline stocks have been increased to record levels, the demand also is unprecedented. U. S. stocks of gasoline totaled 111,474,000 barrels on March 6, 1948, compared with 106,418,000 barrels on March 8, 1947. This was an increase of approximately 5 percent, but that much gain over a year ago is fully needed, with demand up similarly or more. Virtually all districts have moderately larger inventories of gasoline except the Midwest. In that district stocks totaled 20,696,000 barrels on March 6, 1948, which was less than the 22,244,000 barrels held March 8, 1947.

Public Asked to Help in Holding Down Use of Oil

Seeking the cooperation of the public in conserving supplies of gasoline and fuel oil, Standard Oil Company (Indiana) scheduled a large advertisement on the subject March 24 in 191 Midwestern newspapers with a combined circulation of 12,492,194.

In the advertisement, the company said that for the past two years its expenditures for expanding facilities have been more than twice its earnings. In this way, it indicated, it sought to make supply of oils balance demand. But also needed is the cooperation of the public by holding down consumption as much as possible, it was pointed out.

The company declared that it was obliged to set up a policy calling for supplying most essential needs for oils ahead of less essential requirements. Thus there will be primary emphasis on supplying military and essential agricultural needs. Limits already have been reached on customers who can be supplied with heating oils, and new installations of oil burners should not be made without definite assurance that supply will be available. Essential transportation requirements will be met, but savings in use are urged. After all essential requirements are met, the remainder of supplies will be distributed equitably among home owners and the motoring public.

The advertisement makes it clear, with the help of drawings, that in order to make sure there will be no shortages of gasoline and fuel oil, the public will have to cooperate and use these products conservatively.

To save gasoline, the public is asked to eliminate unnecessary driving, organize car pools, drive at moderate speeds, avoid fast starts, keep tires properly inflated, and keep cars in efficient operating condition. To save fuel oil, the public is asked to fill tanks next summer, check oil burners for faulty operation, replace badly worn burners, and weatherproof houses for next winter.

Extraordinary Means Used To Maximize Oil Supply

In its vigorous efforts to supply the greatest possible volumes of oils to consumers, the industry has resorted to many extraordinary means, as it did during the war in maximizing supplies.

Among the measures taken lately was the speeding up of the resumption of shipping on the ice-filled inland waterways and coastal waters. Such activities were nearing normal considerably before winter was over, after having started well ahead of schedule, although the past winter was one of the most severe in recent years.

Socony-Vacuum Oil Company, for example, sent a tanker up the Hudson River from New York to Albany with heating oil on February 26. Preceded by an ice breaker, the tanker was the first to go up to Albany since the first of the year. On February 21 a Socony vessel carrying gasoline and fuel oil from Chicago to Milwaukee was the first commercial vessel to use Lake Michigan and the other Great Lakes in the 1948 season. The first self-propelled commercial vehicle to reach Bangor, Maine, was a vessel bringing kerosine and home heating oil from Boston and Portland. As early as February 6 commercial shipping on the Hudson River up to Newburg, N. Y., was opened with a shipment of home heating oil and kerosine. Hudson River shipping up to Poughkeepsie, N. Y., was resumed February 23 with arrival of two motor vessels, one bringing residual fuel oil and the other home heating oil.

The pre-normal reopening of inland waterway navigation was undertaken despite continuing adverse conditions in order to relieve shortages of home heating oil and kerosine. Additional tugs were required on several occasions to assist the oil bearing vessels. In addition, as expected, the vessels suffered minor damage from the extraordinarily heavy ice conditions.

The industry also has been maximizing supply in numerous other ways. Seagoing tankers, moving oils from the Gulf Coast to the Atlantic Seaboard, have been carrying greater than normal shipments under emergency relaxation of the regulations on loading of vessels. Pipe lines are being crowded to capacity, and new lines are being completed as rapidly as materials can be procured. Pending the construction of needed pipe lines, crude oil is being shipped by tank car over long distances, at heavy cost, as from Rocky Mountain and Southwest sources to Midwest refineries. Tank cars are being used as much as possible for long hauls, and tank trucks substituted in many cases for shorter movements usually involving tank cars.

Industry Demands Credit For Exceptional Record

Criticism of the petroleum industry over oil scarcities is unjustified, and on all sides alert oil company executives are challenging such criticism and demanding for the industry the credit that it deserves for exceptional performance under difficult conditions. Typical of statements being made by oil company executives was that of Frank Phillips, chairman of Phillips Petroleum Company, to employes in the March, 1948, issue of *Philnews* employe magazine. "Oil Facts Speak for Themselves," was the title of the discussion.

"The fact is," he said, "that the oil industry is now carrying the biggest load in its history, even greater than during the war. It is doing this with facilities which, for the most part, have grown old and inadequate. Since the day its war duty ended, the industry has pushed to the limit, almost regardless of costs, to build capacity as fast as requirements have expanded. Probably no other basic industry has been so aggressive in this respect."

Consumption of petroleum is one-third greater than before the war and considerably above the highest peak during the war, he declared. Farm consumption has doubled in six years. There are 1 million more heating installations in homes and buildings than before the war, and therefore distillate usage has jumped 69 percent during the period. Since 1941, the last prewar year, consumption of gasoline has increased 20 percent; industrial fuel oils 31 percent; kerosine 49 percent; aviation gasoline 100 percent; diesel fuels 182 percent; bottled gas 208 percent (now in 4½ million homes); and military use of petroleum products is seven times the prewar rate. There are 1 million more tractors and a greatly increased number of heavier types of trucks and busses than before the war. Of 1000 railroad locomotives now on order, 95 percent will use diesel fuel.

Neither crude oil reserves nor annual production has declined, asserted Phillips. On the contrary, oil reserves have been increased 1¼ billion barrels since the war and crude production has jumped ½ million barrels a day during the past year alone.

"In my opinion," concluded Phillips, "the following things will go a long way toward solving the present situation: (1) time for the industry to catch up, (2) steel with which to drill and build; (3)

the "New Look"

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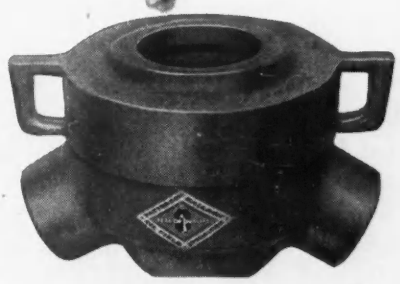

A "New Look" in Sucker Rod Wipers is more than just a change in appearance. It means that this model of the popular line of Patterson-Ballagh Sucker Rod Wipers has been improved to do a better job of stripping paraffin from rods, squares and couplings for you.

The main wiping rubbers are sealed in the body so that no oil leaks on the floor. The rubber grips the sucker rods in such a manner that the rods are wiped clean no matter how fast the string is pulled. They will seal against all but excessive gas pressures and will allow oil to flow to tank if the well makes a head.

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selling prices commensurate with the costs involved; (4) cooperation and conservation on the part of consumers, and (5) freedom for the industry to work out its problems without unnecessary interferences."

Nation Cannot Rely on Oil Alone for Fuel and Power

The new interruption of coal mining at the middle of March put into the spotlight the extra burden imposed on the petroleum industry by failure of the coal industry to do its part in supplying the nation's fuel and power needs. Repeated strikes of coal miners have caused many industrial, commercial, and domestic consumers to quit depending on coal by becoming users of oil and gas.

Oil is being sought in greatly expanded volume not only by motorists and other old-time users but also by those wanting it for home heating, power generation, fueling diesel locomotives, and other uses formerly involving coal. A railroad man has said that John L. Lewis has been the best salesman the diesel manufacturers have ever had.

Several oil company executives have gone on record, before congressional committee hearings and otherwise, as denying in effect that the petroleum industry is obligated to make up for the shortcomings of the coal industry. They acknowledged petroleum industry responsibility for suplying reasonable requirements of oils that have no satisfactory substitutes, as for transportation and military use. But they challenged the wisdom of even trying to furnish petroleum in unlimited volume so that it could be burned under boilers and in furnaces instead of coal, which serves virtually as well for such use.

At the congressional committee hearings the warning was sounded that the country cannot continue to rely on petroleum alone for meeting increased power and fuel needs. It was stated that the country would either have to cut down the demand for petroleum or find an alternative source of fuel.

As an example of sharply increased demand for oil, use of diesel oil by railroads is being greatly expanded. At the beginning of this year Class I railroads had outstanding orders for 1226 new locomotives and only 30 of them or 2.5 percent were for the steam type, while the rest were for diesels. Locomotive manufacturers are asking the government if they should go ahead and convert plants wholly to diesel locomotive manufacture or if defense plans and oil supply problems require keeping steam locomotive facilities in standby condition. Insofar as diesels replace oil-burning steam locomotives, there will be a net saving rather than increase in oil use. But where the diesels replace coal-burning steam locomotives, the demand for oil is increased.

The petroleum industry is primarily a supplier of fuels for transportation, but there is some question of the wisdom of this dieselizing of the railroads,

Two Committees Study Oil Supply Problems

Through two subcommittees of its National Oil Policy Committee, the American Petroleum Institute is working on two studies of the nation's available supplies of petroleum. One committee will deal with the supplies for the current year and next winter's heating season. The other will deal with the supply problem of the next 10 to 15 years. It is contemplated that the studies "will constitute a report to the nation of everything the American petroleum industry knows on the subject," said API President William R. Boyd, Jr.

The short-range study will be made by a group of petroleum economists and executives headed by Howard W. Page, of Standard Oil Company (New Jersey), chairman. The long-range study will be made by a similar group headed by L. F. McCollum, president of Continental Oil Company, as chairman.

Suspension of Connally Hot Oil Act Is Opposed

Men of the petroleum industry as well as members of the state oil conservation commissions deny that any good would come from the proposal of Senator Kenneth S. Wherry (Republican, Nebraska) that President Truman set aside operation of the Connally hot oil act, for the purpose of making greater supply of oils available and of holding down prices. Wherry is chairman of the Senate's small business committee, which has been studying oil shortages. The committee heard allegations that state proration was being used to limit production, cause shortages, restrict competition, and increase prices. The committee said that the President could step up production of petroleum products to the point of national demand, by a proclamation declaring the Connally Act inoperative because petroleum moving in interstate commerce is less than national demand. Purpose of the law is to bar from interstate commerce oil produced in violation of state oil conservation regulations.

There is a provision in the Connally Act saying that the President has the power to suspend the operation of the Connally Act if he finds that the oil-producing states which prorate production are limiting production below national demand and thus unjustly enhancing the price.

Oil industry spokesmen have denied that production is being held down below efficient producing ability for the sake of higher price. Colonel Ernest O. Thompson, chairman of the Texas Railroad Commission, asserted that not a single barrel of additional production would be made available in Texas by suspension of the Connally Act. Texas has consistently set allowables above Bureau of Mines estimates of demand, he said, and such restrictions as there are upon production take into consideration the producing ability of the wells and the danger of damaging them by overproduction.

If the President should declare the Connally Act to be inoperative, it would be a "completely empty gesture," said Thompson, because "we are producing currently and have been for more than two years all of the oil that can be produced at the most efficient rate of production from Texas fields."

Thompson said that hearings would be held promptly if it could be shown that more production could be obtained without drop in bottom-hole pressure or increase in gas-oil ratio. Where this can be shown, he continued, field allowables will be increased. The Texas commission chairman further expressed the belief that no producer was holding back any oil. "No one holds oil back at $2.65 a barrel," he said.

Industry Ahead of Ickes In Solving Oil Problems

Because Harold L. Ickes was petroleum administrator for war and Secretary of Interior under President Roosevelt, his testimony before the House of Representatives armed services subcommittee, critical of the industry, was challenged by R. B. Anderson, of Vernon, Texas, president of the Texas Mid-Continent Oil and Gas Association.

Anderson declared that Texas oil men need no prodding from the federal government or Ickes to seek new petroleum reserves or to develop new fuels. The industry already is spending billions of dollars to develop new reserves, he asserted, while currently producing unprecedented volumes from present reserves that were developed wholly by private companies without prodding from Ickes or anyone else.

Furthermore, Anderson declared, the oil companies already are far, far ahead of any government agency in the development of synthetic fuels, and they have done this on their own initiative and with their own money.

Reserves "roped off" for future emergencies, as suggested by Ickes, actually would be of very little value in an emergency, because it takes time to develop reserves and put them to use, asserted Anderson.

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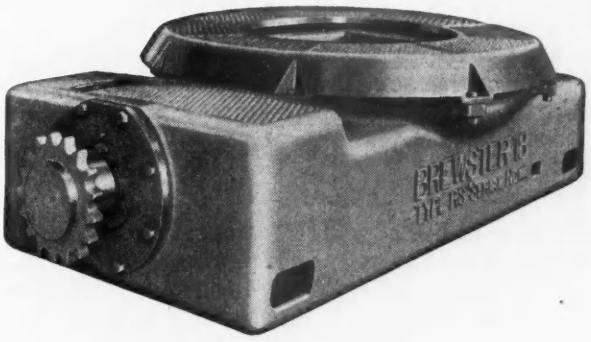

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Oilbath ROTARIES

Looking Ahead

- IT MAY be mid-April or later, if ever, before Department of Commerce proposes to steel industry that it allocate to petroleum industry any part of the 15,571,500 tons of steel products oil men say they need in the next 18 months (see page 57). Commerce Department objects that estimates should be supported with more specific evidence; that requirements should be set forth more in terms of actual projects and less in broad industry groupings.

- DESPITE COMMODITY price declines, business will continue at high level through first half of year. Any declining tendency in latter half will not cause material recession in this calendar year. Most of the business indexes probably will average about as high in 1948 as in 1947. We are entering last phase of upward swing of this business cycle. But this phase will be a long one. Both business and prices may not yet be at their peaks. These views were expressed by Alan H. Temple, vice president of the National City Bank of New York.

- ALTHOUGH SOME companies plan to import Middle East crude to help meet East Coast demand, it will be later in the year before tanker transportation becomes available for this purpose. However, the tanker shortage has been materially relieved by putting back into service formerly tied up Maritime Commission tankers.

- ANOTHER "BIG INCH" pipe line may be built within three years to take more Texas gas into Southern California. Because of accelerated demand influenced primarily by rapidly increasing population capacity of the present 24- and 30-inch line, completed only last year, is being stepped up. Its maximum rated capacity of 305 million cubic feet per day is expected to be reached by the first of next year.

- THE LOOKED-FOR Guatemalan oil law became effective with its publication in the official journal March 2, but as written contains provisions tending to discourage large scale-development by foreign capital (see page 218).

- STIMULATION of domestic exploration depends on reliance of American demand upon American production, according to Bernard Brodie in a monograph on "American Security and Foreign Oil." He says that the direct strategic value of Middle East oil to the U. S. has been overstressed (see page 226).

- THE CARIBBEAN AREA will continue for a long time as the single foreign source most important to world petroleum economy. Looking ahead four to five years American economists see that area still producing more than the Middle East, even with the now improbable completion of one of the major pipe lines to the Mediterranean.

- PARTICIPATION of several of the larger oil companies in research programs looking toward the use of radioisotopes in petroleum processing is expected to speed up the development of new methods for tracing changes in reservoirs during production and secondary recovery, and thus to assist in obtaining maximum return from the formation.

REFINING CAPACITY?

STEEL SUPPLY?

MIDDLE EAST PRODUCTION?

TANKER PROBLEM?

WORLD SUPPLY-DEMAND PROSPECTS 1951-57

CONSERVATION PROGRAMS?

U. S. SUPPLY-DEMAND GROWTH?

By HENRY OZANNE, Staff Writer

WHAT level will world demand for petroleum reach in the next few years? What available supplies can be forecast against that demand? And what world-wide movements of oil are foreseen in satisfying the demand?

This broad question is the inquiry of this article which is a summary presentation of current industry and government thinking on the problem. The following analysis attempts to answer the question: "How much oil will be required worldwide, and what will be its source and the pattern of its distribution?

The conclusions offered here are initial ones. In the course of the next six months the problem will be explored fully and systematically in many industry quarters, and final industry views as they shape up will be reported in succeeding articles. Many companies are just beginning their own surveys, including the Standard Oil Company (N. J.) which is embarking on a three-month, world-scale research project on petroleum demand and supply. Other companies, including Socony-Vacuum Oil Company, are just completing such surveys, results of which have not yet been disclosed. One of the most fruitful investigations will be that just launched by the American Petroleum Institute, whose National Oil Policy Committee has named two subcommittees, one to work on "short-range" petroleum prospects, the other on "long-range" prospects. Both surveys will be conducted on a global basis.

One important assumption underlies this article—the future availability of Middle East oil is taken for granted. At the moment, all industry figures, the Marshall Plan and other commodity commitment proposals are predicated on access to Middle East petroleum sources. The assumption grows more precarious daily, and some government officials told the writer they may call at any time for an over-all petroleum report with the Middle East "written off." In that event the structure of the argument of this article, from premises to conclusion, would collapse.

Implemented Demand

One other caution: economists are tending to make a radically revised definition of the old terms "supply" and "demand." "Demand" in "classical" petroleum economics presumed an effective and existing market, and "supply" was a concept of the adjustment of production and distribution to the market requirement. Now, the supply of petroleum is the determinant of its demand—a reverse condition and process. "Demand" itself has come to have two sharply distinguishable meanings—"potential demand" and "implemented demand." The former merely means how much oil could be consumed without consideration of any restriction, other than price, involved. Much blue-printing of world petroleum needs has been drawn on this basis, and all recent approaches to the Marshall Plan have been concerned largely with paring down "demand" quotas, in this sense, to realistic budget items. "Implemented demand" is a new term arising in industry, somewhat akin to the old term "effective demand." But while "effective demand" considered only the market limitation in terms of price, "implemented demand" means how much oil can be consumed in the light of production, transportation, refining and marketing difficulties now existing.

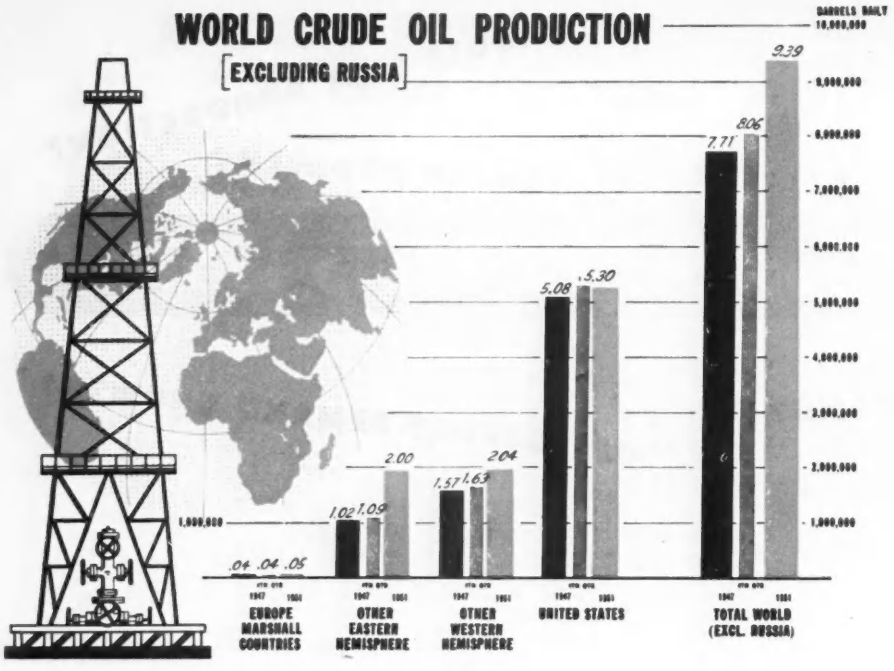
This is highly important because with the new usage, there is a tendency to convergence in both sets of figures. That is, the question investigated is one more properly designated as "balance," and our original question may be put more meaningfully: "What are the balance prospects, worldwide, between supply and implemented demand of petroleum in the next few years?"

The conclusions of this article will be set forth with reference to two different time-periods: 1951-1952 and 1955-1957. The discussion will be on hemispheric or continental level, not on a country-by-country basis.

World petroleum demand estimates for 1951-1952, as they now reflect industry thinking, vary from 10 million barrels a day to around 10.7 millions a day. Other followers of industry statistics forecast a figure as high as 11.3 million barrels a day in the next three or four years. This figure, however, is at least 5 percent too high, in the opinion of some industry economists. Nevertheless, industry figures lately have tended to be conservative and have shown an upward trend in time. For instance, B. B. Jennings, president of Socony-Vacuum, presented to the API meeting in November a forecast for 1950 of 3.2 million barrels a day, excluding Russia and the U. S., and a 1960 forecast of 4.5 million barrels daily; but now he has revised these figures upward.

Government foresasts, usually still more conservative, are in close agreement with this order of estimate. Interior Secretary Krug, presumably on data furnished by his Oil and Gas division, estimates a world demand of 10 million barrels daily before 1951, and something in excess of that amount during 1951. The latest government estimates, included in the so-called Executive Branch report on the Marshall Plan, put world demand at just over 10 million barrels a day in 1951.

(In these computations Russia is generally excluded because Russian oil is not expected to play a part on the world



scene outside the Soviet Union. The Soviet Five-Year Plan calls for a crude output by Russia of about 700,000 barrels a day in 1950.)

C. J. Bauer, of the Coordination and Economics Department of the Standard Oil Company (N. J.), anticipates a 1951 annual world demand of slightly under 4 billion barrels (10.7 million barrels a day), an increase of 23 percent over 1947. His figures are among the most recent from industry sources and exhibit the "upward trend" in present forecasting. He sees a 1951 world demand outside the U. S. at 4.4 million barrels a day, and demand in the U. S. at 6.3 millions a day. Bauer also predicts that Western Hemisphere requirements, excluding the U. S., in 1950 will reach 1 million barrels a day for the first time, and will rise to better than 1.1 million barrels daily in 1951.

E. T. Knight and George Buchwald, economists of The Atlantic Refining Company, have prepared for WORLD OIL the 1952 forecast breakdown shown in Table 1.

Dr. Joseph E. Pogue, vice president of Chase National Bank, and Frederick G. Coqueron of that bank's petroleum department, both well-known oil industry economists, predict a 1951 U. S. demand of 6 million barrels a day, and a total foreign demand of 4.2 million a day, making a worldwide demand of 10.2 million barrels daily, a 32 percent increase over 1946. Against this they forecast a 1951 supply of 5.5 million barrels daily in the U. S., and 4.8 million barrels outside the U. S., making a total of 10.3 million barrels a day, or a leeway of 100,000 barrels daily of supply over demand.

A well-known economist of a major oil company prepared for WORLD OIL a tabular analysis closely in line with the above figures. His forecast is set forth in Table 2.

All the analysts agree that the demand rate of growth over the next three or four years will be greater outside the U. S. than in this country. Bauer says, "The foreign areas are expected to stage a sharp comeback in this period and by 1951 will be using slightly over 40 percent of the world's petroleum supplies." Dr. Pogue estimates that oil consumption in the U. S. will increase from 4.9 million barrels a day in 1946 to 6.7 million a day in 1956, an expansion of 37 percent. "Over the same period," he says, "consumption of oil in the rest of the world is estimated to show a growth of 76 percent."

U. S. Supply-Demand

One presently controversial point is the estimated supply-demand growth within the U. S. What will domestic requirements be, and how far will domestic production be able to meet those requirements over the next decade? Virtually all industry sources except the Independent Petroleum Association of America see increasing reliance on imports to satisfy domestic demand. This question, however, involves several variables, including such intangible factors as the influence of conservation programs. An economist of a major company estimated for WORLD OIL that 1.5 million barrels a day of liquid fuels could be saved by the use of solid fuels—"if we had the solid fuels and were under a high enough degree of compulsion to make the saving."

The question is better put in this way: "What part of the increment of demand for energy in the U. S. will be assumed by coal rather than by oil?" For the U. S., this economist sees a need of 700,000 barrels a day imports by 1952 necessary to take care of increased domestic demand by that date. Industry economists are allowing about a 6 percent a year expansion in U. S. demand.

For 1955-1957 the demand forecasts are more tenuous and fallible. Knight and Buchwald of Atlantic offer the data in Table 3.

Figures in Table 2, prepared by the economist of another major oil company, are in close agreement, as are those of Dr. Pogue, who forecasts 11.8 million barrels a day demand by 1956.

All these statistics also tend to "balance out" supply and demand, as noted in the beginning of this article. The Atlantic economists balance out exactly

TABLE 1
1952 (in thousands of barrels a day)

	Demand	Supply	Surplus	Deficit
United States	6900	6060	....	840
North America	7520	6260	....	1260
South America	540	2000	1460	....
Europe (Ex. USSR)	1400	100	....	1300
Africa	250	50	....	200
Middle East	230	1930	1700	....
Far East (Ex. USSR)	360	20	....	340
Oceania	310	250	....	60
Total World	10,610	10,610	3160	3160

TABLE 2
World Supply and Demand for Petroleum and Products
(THOUSANDS OF BARRELS DAILY)

	1947	1951-52	1955-56
DEMAND:			
United States	5,460	6,500	6,900
Other Western Hemisphere	900	1,100	1,250
Total Western Hemisphere	6,360	7,600	8,150
Europe—Marshall Countries	800	1,400	1,650
Other Eastern Hemisphere*	970	1,100	1,200
Total Estern Hemisphere	1,770	2,500	2,850
Total World*	8,130	10,100	11,000
SUPPLY:			
United States†	5,440	5,900	6,000
Other Western Hemisphere	1,560	2,000	2,100
Total Western Hemisphere	7,000	7,900	8,100
Europe	35	50	50
Middle East	810	1,600	2,500
Other Eastern Hemisphere*	205	350	350
Total Eastern Hemisphere*	1,050	2,000	2,900
Total World	8,050	9,900	11,000
WORLD SHORTAGE	80	200	.....

* Excludes Russia.
† Includes 360,000 B/D of natural gasoline, condensate, etc. in 1947 and 400,000 B/D in 1951.

TABLE 3
1957 (in thousands of barrels daily)

	Demand	Supply	Surplus	Deficit
United States	7700	6000	.....	1700
North America	8475	6250	.....	2225
South America	675	2500	1825	.....
Europe (Ex. USSR)	1700	100	.....	1600
Africa	310	50	.....	260
Middle East	290	3060	2770	.....
Far East (Ex. USSR)	450	30	.....	420
Oceania	390	300	.....	90
Total, World	12,290	12,290	4595	4595

their figures for both 1952 and 1957, while Table 2 shows only a 200,000 barrel a day off-balance by 1951 and complete adjustment by 1955-1956.

Forecasts for 1957 involve a number of variables that make the estimates rather "iffy." No figures beyond 1957 are as yet anything more than guesses. In the next few months industry hopes to give greater substance and specificity to 1957 estimates and even to project still furtheir ahead.

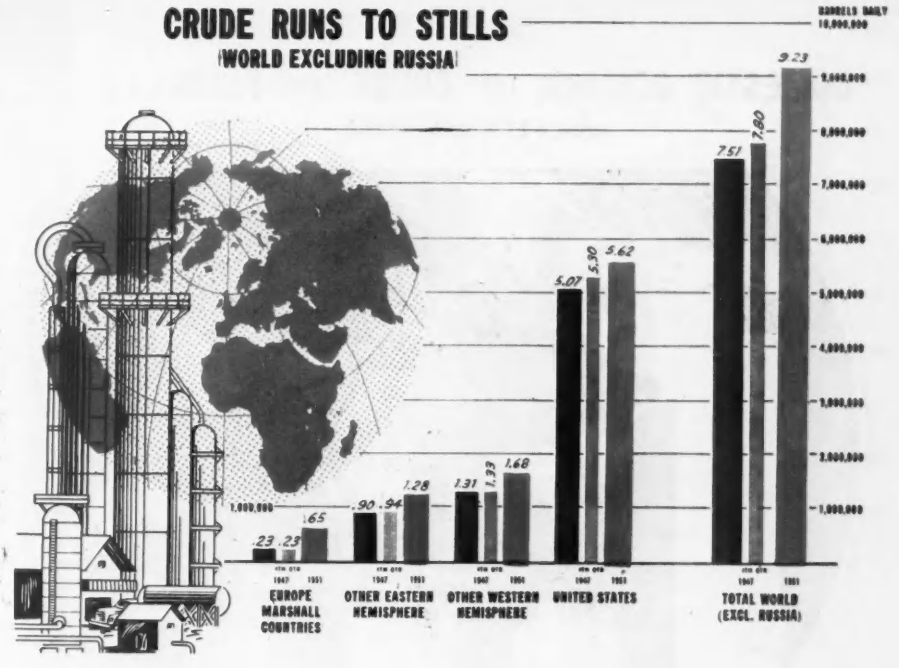
It is obvious that the biggest uncertainty in both the 1951-1952 picture and that of 1955-1957 is the Middle East. The entire solution to the problem of world balance of petroleum demand and supply is predicated on the flow of oil from the Middle East. The only variables allowed at the present time are those affecting that flow in "what quantities," "by what means" and "when."

In 1947 the Western Hemisphere shipped a net difference of 700,000 barrels a day to the Eastern Hemisphere, most of which were exports from the Caribbean and which included 100,000 barerls of crude. As Middle East crude becomes available, it is intended to back out that 100,000 barrels a day, so that by the end of 1948 or early 1949 crude shipments both ways should balance, except for specialty exchanges.

There is no question but that adequate production is assured in the Middle East if operations there are permitted to go unhampered. American interests in the Middle East are most directly represented in Saudi Arabia in the Arabian American Oil Company which eventually is to include the participation of The Texas Company, the Standard Oil Company (California) and the Standard Oil Company (N. J.), all in the ownership ratio of 30 percent, and The Socony-Vacuum Oil Company, as 10 percent owner. James Terry Duce, vice president of Arabian American Oil Company (Aramco) presented the figures in Table 4 to show the rate per well at which oil is being produced in various parts of the world.

Duce says Aramco plans "to bring our production available on the Persian Gulf up to 500,000 barrels a day by July 1, 1949. This, of course, depends on whether we get the materials promptly for the building of stabilizer and other facilities." Further, he says, Aramco can increase production 100,000 barrels a day per year from 1949 onward, but he adds: "Whether this will be done of course depends on whether tankers are available both in the Gulf and on the Levant coast to take the oil away."

Whether the Middle East can achieve the production goals set for it hinges on three factors (barring all political contingencies): the pipe line program, tanker availability and refining capacity



in the Eastern Hemisphere, in Europe and in the U. S.

All estimates of a 1951-1952 balance are based on Middle East production of something in excess of 1.5 million barrels a day, and this production in turn is dependent on transportation facilities. The pipe line program has been considered the key to this movement.

Three big pipe lines are figuring definitely in the Middle East movement and two others are projected. The three scheduled lines are (1) the new 16-inch pipe system of Iraq Petroleum Company to parallel the existing 12-inch lines from the Kirkuk fields to Haifa and to Tripoli; (2) Aramco's Trans-Arabian Pipe Line from the Persian Gulf to Sidon, Lebanon; (3) the Middle East pipe line from the Kuwait and Iran fields to the Eastern Mediterranean. All of these lines, with a total capacity of about 1 million barrels a day initially, were to go in operation between 1949 and 1950. All the projects are threatened with delays.

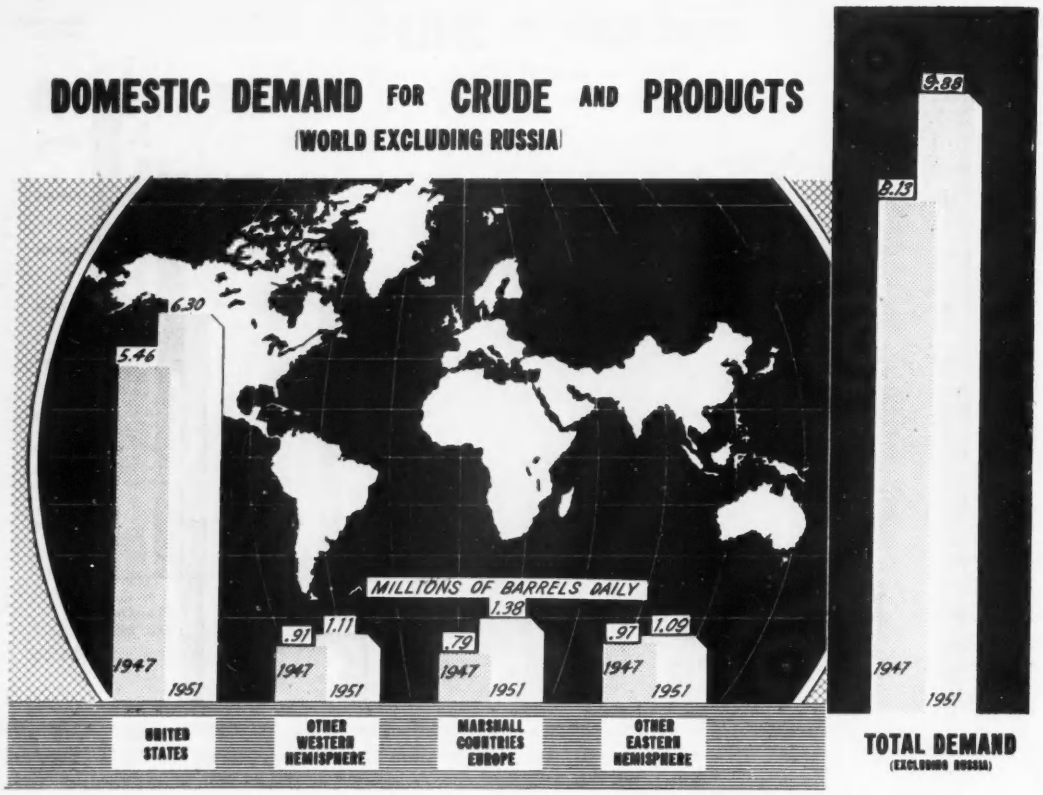
The IPC line, first to get into the construction stage last year, is bogged down by shortages and political difficulties after 350 miles of it were laid in the ditch on the south leg from K-1 through Iraq and Trans-Jordan. Opening of the line has been deferred nearly a year, and if the Palestine trouble continues, interrupting completion of the south leg, the delay may run to two years because of pipe shortage for the north leg. Trans-Arabian Pipe Line Company still insists it plans to finish its system in 1950 and actually is at work in Saudi Arabia. But the company has as yet failed to get transit rights from Syria after a year of negotiation. The Middle East company has not even entered into negotiations for rights and presumably will be still further behind in its program.

In the latter part of March much doubt arose as to whether work would be continued at all on the Trans-Arabian pipe line, in view of recent political developments. It was indicated that the U. S. government might withdraw approval and support of "Tapline," and ask that the steel involved be diverted to construction of tankers. Owners of the line meanwhile stood ready to use pipe already received in the Middle East for delivering crude down to the Persian Gulf, if necessary. There was talk that the Persian Gulf instead of the Mediterranean might have to be the tidewater outlet for Middle East oil, as in the past.

The whole matter was very complex, with far-reaching ramifications. It was complicated by the question of the partitioning of Palestine, which the U. S. originally approved but recently disapproved, and by the menacing moves of Soviet Russia in Italy and toward Iran. Members of the U. S. Congress were asking military men whether the Arabian oil fields could be successfully defended in the event of a conflict with Russia, and the answers were noncommittal. High government spokesmen also pointed out that over-all U. S. policy

TABLE 4

COUNTRY	Production in b/d	Producing Wells	Average Production per Day per Well in Barrels
Middle East:			
Bahrein	29,000	68	426
Iran	405,000	57	7,105
Iraq	97,000	11	8,818
Kuwait	61,000	11	5,545
Saudi Arabia	299,000	42	7,119
Colombia	70,000	1,460	48
Mexico	153,000	1,015	151
Venezuela	1,250,000	5,129	244
U. S.	5,341,000	440,000	12



had to consider not only the hazards and advisability of putting large tonnage of steel into pipe lines across the Middle East but also the greater problem of the continued availability of Middle East oil.

All of this casts serious doubt on the world balance picture for 1951-1952. As Bauer says: "To balance world supply, we anticipate a Middle East production of over 1.6 million barrels a day by 1951, or more than double the 1947 record. If the pipe lines are not completed, the estimated requirements previously discussed cannot be met."

Furthermore, the tanker problem is far from solved. There are about 1000 tankers in the world, the equivalent of the T-2 type and available for petroleum transportation, according to a recent analysis by M. G. Gamble of the Marine department of Standard Oil Company (N. J.). There are on order about 31 T-2's in the U. S. and 148 in Europe, but delivery of the first vessels from U. S. yards will not take place before 1949. European deliveries are being greatly retarded, says Gamble, who estimates that by 1951 "there should be available to industry total tonnage equivalent to about 1150 T-2's."

Gamble concludes: "Over the next few years, the existing tanker fleet, augmented by presently scheduled construction, cannot accommodate estimated long-term requirements, and further new tanker construction either here or abroad is needed to serve as a balancing factor to cover the increasing requirements and replacements needed to offset the retirements from obsolescence."

To whatever extent the Middle East pipe line program is delayed or disrupted, the tanker problem becomes more urgent. Aramco's Trans-Arabian line is computed as the equivalent of 60 T-2's, and Middle East Pipe Line, Inc., project as the equivalent of 20 tankers. Duce estimates that the transport of 450,000 barrels a day of crude, the possible later throughput of Aramco's line, to the Eastern Mediterranean, would require 88 T-2 tankers.

One other immediately restricting factor in world balance is the extremely important one of refining capacity. Supply and demand estimates of all the experts are based on the assumption that Western Hemisphere refining capacity will be coming on stream in sufficient amount to take care of extra demand. In fact, the entire recovery plan assumes that Europe will receive not more, but less products from the United States as European plant expansion progresses.

Industry economists see a refinery capacity increment outside the U. S. of about 300,000 barrels a day for 1948 over 1947. This increment includes all foreign additions, representing about 200,000 barrels a day for the Eastern Hemisphere and only 75,000 barrels a day extra for Europe. By 1951 it was planned that large plant additions would allow sharp cutback in U. S. shipments to Europe. Whereas in 1946 the Western Hemisphere supplied 77 percent of Europe's petroleum imports and the Middle East 23 percent, it is estimated in the Executive Branch analysis of the Marshall Plan that in 1951 Europe will draw over 80 percent of its oil needs from the Middle East and less than 20 percent from the Western Hemisphere. Bauer expects refinery runs outside the U. S. to increase on the average of 400,-

■ CONTINUED ON PAGE 50

TABLE 5

Estimated World Movement of Crude Petroleum and Products in 1952 and 1957
(Table prepared by Knight and Buchwald of The Atlantic Refining Company)
(THOUSANDS OF BARRELS DAILY)

FROM	TO U.S.A.	North America	South America	Europe Except U.S.S.R.	Africa	Middle East	Far East	Oceania	Russia	TOTAL EXPORTS
1952:										
United States	.....	160	.....	*100	.....	.....	.....	.....	.....	260
North America (inc. U.S.A.)	.....	.....	.....	*100	.....	.....	.....	.....	.....	*100
South America	1,100	1,360	.....	100	.....	.....	.....	.....	.....	1,460
Europe exc. U.S.S.R.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Africa	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Middle East	.....	.....	.....	1,100	200	.....	340	60	.....	1,700
Far East exc. U.S.S.R.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oceania	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
TOTAL IMPORTS	1,100	1,360	.....	1,300	200	.....	340	60	.....	3,260
1957:										
United States	.....	80	.....	*100	.....	.....	.....	.....	.....	180
North America (inc. U.S.A.)	.....	.....	.....	*100	.....	.....	.....	.....	.....	*100
South America	1,480	1,825	.....	.....	.....	.....	.....	.....	.....	1,825
Europe, exc. U.S.S.R.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Africa	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Middle East	400	500	.....	1,500	260	.....	420	90	.....	2,770
Far East	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oceania	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
TOTAL IMPORTS	1,880	2,325	.....	1,600	260	.....	420	90	.....	4,695

* Consisting mainly of lubes, waxes, and specialties to be distributed all over the world, but lumped as exports to Europe for the purpose of simplifying the table.

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United States Reserves

GAS

in Relation

By L. J. LOGAN

IN SPITE of comparatively high rates of field development and wildcatting in 1947, the proving up of reserves of natural gas and natural gas liquids in the U. S. was not sufficiently successful to prevent declines during the year in reserves of both resources in terms of years' supply at prevailing rates of production.

In terms of actual cubic feet and barrels, there were small net increases in these reserves, after figuring in the year's production. But these were far too small to leave as many years' supply of reserves at the end of the year as at the beginning. For production of both natural gas and natural gas liquids was sharply higher in 1947 than in 1946, and without reduction in years' supply of reserves, the reserves would have had to be increased much more greatly than they actually were.

It should be added, however, that the

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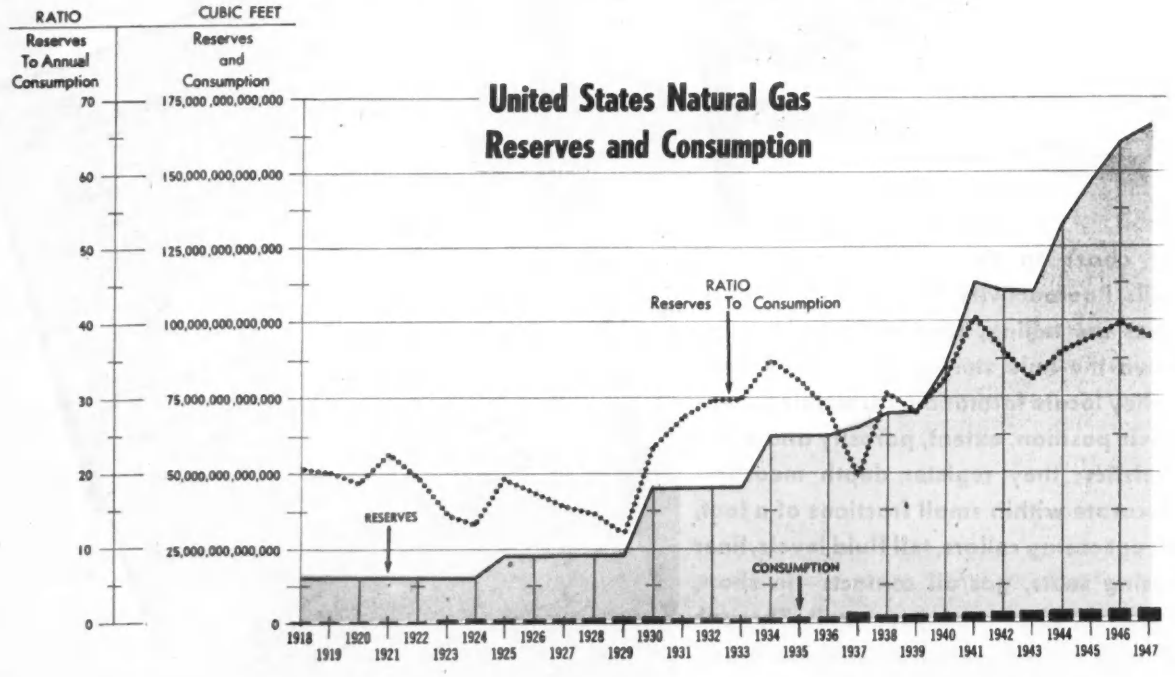


YEAR	Reserves at End of Year (Billions of Cubic Feet)	Authority for Estimate of Reserves	Consumption During Year (Marketed Production: Billions of Cubic Feet)	Years' Supply in Reserve
1918...	15,000	E. Holley Poe et al in report	721	20.8
1919...	15,000	September 23, 1947	746	20.1
1920...	15,000	" " "	798	18.8
1921...	15,000	" " "	662	22.7
1922...	15,000	" " "	763	19.7
1923...	15,000	" " "	1,007	14.9
1924...	15,000	" " "	1,142	13.1
1925...	23,000	*Gas Facts, 1945 and 1946*	1,189	19.3
1926...	23,000	" "	1,313	17.5
1927...	23,000	" "	1,445	15.9
1928...	23,000	" "	1,568	14.7
1929...	23,000	" "	1,918	12.0
1930...	46,000	Earl P. Hindes, then Cities Service	1,943	23.7
1931...	46,000	Co.	1,686	27.3
1932...	46,000	" " "	1,556	29.6
1933...	46,000	" " "	1,555	29.6
1934..	62,000	Ralph E. Davis, Consulting Engineer	1,771	35.0
1935..	62,000		1,917	32.3
1936..	62,000	" " "	2,168	28.6
1937..	66,000	" " "	3,408	19.4
1938..	70,000	Lyon F. Terry, Chase Nat'l. Bank	2,296	30.5
1939..	70,000	" " "	2,477	28.3
1940..	85,000	Ralph E. Davis, Consulting Engineer	2,660	32.0
1941..	113,800	Petroleum Administration for War	2,813	40.5
1942..	110,000	" " "	3,053	36.0
1943..	110,000	" " "	3,415	32.2
1944..	133,500	" " "	3,711	36.0
1945..	147,789	American Gas Association	3,919	37.7
1946..	160,576	" "	4,040	39.7
1947..	165,927	" "	4,400	37.7

Unsatisfactory—

OIL

to Production

Associate Editor

ALTHOUGH there was unprecedented wildcatting and near-record field development in 1947, the payoff by way of proving up new crude reserves was less than satisfactory. New reserves somewhat more than compensated for production during the year, but the 2.9 percent net gain in reserves was much less than the 7.2 percent increase in the annual rate of production. While U. S. crude reserves of 21,487,685,000 barrels at the end of 1947 represented a new all-time peak, they were equivalent to only 11.6 years' supply on the basis of the production of 1,850,445,000 barrels in 1947. The reserves of 20,873,560,000 barrels at the end of 1946 had been equivalent to 12.1 years' supply on the basis of the production of 1,726,348,000 barrels in 1946.

This decline in crude reserves on a years' supply basis was the most significant trend revealed by the annual estimates of reserves of crude oil, natural gas liquids, and natural gas, recently made public by the American Petroleum Institute and the American Gas Association. (The API estimated crude reserves and the AGA natural gas, and they collaborated on the estimates of natural gas liquids.)

This dwindling of years' supply of crude in reserve, in the face of exceptionally active drilling, overshadowed other interpretations of the year's results. Thus it did not mean a great deal that crude reserves proved up in 1947 nearly (not quite) equaled the relatively favorable provings of 1946 and were above other recent years except 1937 and 1938. Likewise, it did not necessarily mean something to boast about in noting that the proved reserves at the end of 1947 were the greatest in history. The point that must not be overlooked is that production is running higher than ever before and headed still higher. Considering present high production rates, it would be alarming if reserves were not greater than in the past.

In the three decades since 1918, proved U. S. reserves have sometimes been as

TABLE 1

Summary of Changes in 1947 in Proved U. S. Reserves of Crude Oil, Natural Gas Liquids, and Total Liquid Hydrocarbons (All Oils)

Estimates on crude oil from American Petroleum Institute; and on natural gas liquids and total liquid hydrocarbons from American Gas Association and American Petroleum Institute, working together.

(Barrels of 42 U. S. Gallons)

CRUDE OIL		
Total proved reserves of crude oil as of December 31, 1946		20,873,560,000
Revisions of previous estimates	+749,278,000	
Extensions of old pools	1,269,862,000	
New reserves (new pools) discovered in 1947	445,430,000	
Proved reserves add in 1947		2,464,570,000
Total proved reserves as of December 31, 1946, plus new proved reserves added in 1947		23,338,130,000
Less production during 1947		1,850,445,000
Total proved reserves of crude oil as of December 31, 1947		21,487,685,000
Increase in crude oil reserves since December 31, 1946		614,125,000
NATURAL GAS LIQUIDS		
Total proved reserves of natural gas liquids as of December 31, 1946		3,163,219,000
Revisions of previous estimates and extensions of old pools	+192,237,000	
New reserves (new pools) discovered in 1947	59,301,000	
Proved reserves added in 1947		251,538,000
Total proved reserves as of December 31, 1946, plus new proved reserves added in 1947		3,414,757,000
Less production during 1947		160,782,000
Total proved reserves of natural gas liquids as of December 31, 1947		3,253,975,000
Increase since December 31, 1946		90,756,000
TOTAL LIQUID HYDROCARBONS		
Total proved reserves as of December 31, 1946		24,036,779,000
Revisions of previous estimates and extensions of old pools	+2,211,377,000	
New reserves (new pools) discovered in 1947	504,731,000	
Proved reserves added in 1947		2,716,108,000
Total proved reserves as of December 31, 1946, plus new proved reserves added in 1947		26,752,887,000
Less production during 1947		2,011,227,000
Total proved reserves of liquid hydrocarbons as of December 31, 1947		24,741,660,000
Increase since December 31, 1946		704,881,000

TABLE 2

Estimated Proved Reserves of Crude Oil in the United States

(Barrels of 42 U. S. Gallons) (A.P.I. Committee)

	Proved Reserves as of December 31, 1946 (1)	Changes in Proved Reserves Due to Extensions (New Oil) and Revisions During 1947 (2)	Proved Reserves in New Pools Discovered in 1947* (3)	Production During 1947 (4)	Proved Reserves as of December 31, 1947 (Columns 1+2+3 Less Column 4) (5)	Change in Reserves During 1947 (Column 5 Less Column 1) (6)
Alabama	512,000	2,652,000	.....	405,000	2,759,000	2,247,000
Arkansas	267,058,000	56,485,000	1,287,000	27,922,000	296,908,000	29,850,000
California	3,293,491,000	321,281,000	13,355,000	333,164,000	3,294,963,000	1,472,000
Colorado	299,870,000	97,524,000	160,000	15,672,000	381,882,000	82,012,000
Illinois	351,264,000	62,464,000	8,853,000	67,220,000	355,361,000	4,097,000
Indiana	44,070,000	7,507,000	1,580,000	7,142,000	46,015,000	1,945,000
Kansas	545,316,000	102,248,000	19,131,000	104,017,000	562,678,000	17,362,000
Kentucky	59,188,000	12,189,000	2,770,000	9,597,000	64,550,000	5,362,000
Louisiana	1,651,797,000	238,940,000	57,547,000	157,280,000	1,791,004,000	139,207,000
Michigan	69,177,000	8,136,000	8,762,000	16,361,000	69,714,000	537,000
Mississippi	270,221,000	68,334,000	24,000	34,902,000	303,677,000	33,456,000
Montana	104,246,000	16,796,000	2,665,000	9,045,000	114,662,000	10,416,000
Nebraska	875,000	205,000	.....	214,000	866,000	(—) 9,000
New Mexico	543,453,000	24,546,000	3,395,000	40,911,000	530,483,000	(—)12,970,000
New York	76,289,000	.....	.....	4,770,000	71,519,000	(—) 4,770,000
Ohio	29,220,000	3,392,000	.....	3,618,000	28,994,000	(—) 226,000
Oklahoma	898,186,000	114,457,000	82,302,000	141,955,000	952,990,000	54,804,000
Pennsylvania	97,501,000	37,936,000	.....	12,717,000	122,720,000	25,219,000
Texas	11,646,360,000	714,105,000	232,804,000	815,732,000	11,777,537,000	131,177,000
West Virginia	35,655,000	3,100,000	.....	2,663,000	36,092,000	437,000
Wyoming	589,358,000	123,913,000	10,795,000	44,755,000	679,311,000	89,953,000
Miscellaneous†	453,000	2,930,000	.....	383,000	3,000,000	2,547,000
Total U.S.	20,873,560,000	2,019,140,000	445,430,000	1,850,445,000	21,487,685,000	614,125,000

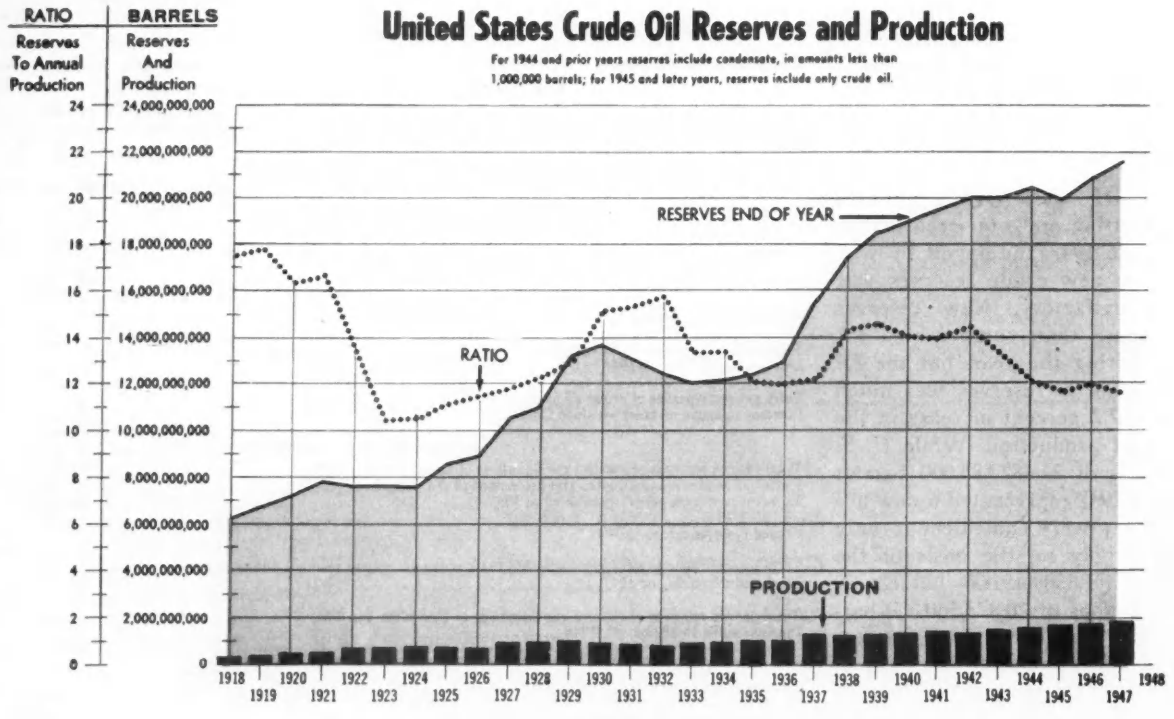
* Only a limited area is assigned to each new discovery, even though the committee may believe that eventually a much larger area will produce, for, in this report, the concern is only with actually proved reserves.

† Includes Florida, Missouri, Tennessee, Utah, and Virginia.

much as 16 or 17 times the prevailing annual production. With the exception of several years in the middle 1920's, they have never been less than 12 times prevailing annual production.

Under the reasonable assumption that U. S. crude reserves should have been maintained in 1947 at least at the end-of-1946 ratio of 12.1 times annual production, it is indicated that at the end of 1947 the reserves should have been at least 22,390,384,500 barrels. Instead, they were actually estimated at only 21,487,-685,000 barrels. This indicated a deficiency of 902,699,500 barrels in reserve finding in 1947.

Instead of proving up the estimated total of 2,464,570,000 barrels of new reserves in 1947, it would have been necessary to block out the 902,699,500 barrels additional, or a total of 3,367,269,500 barrels of new reserves to prevent deterioration of the reserves position. The proving up of reserves would have had to be 36.6 percent more than the actual performance. Reserve-proving would have had to be more than one third



United States Crude Oil Reserves and Production

For 1944 and prior years reserves include condensate, in amounts less than 1,000,000 barrels; for 1945 and later years, reserves include only crude oil.

All Figures in Barrels

YEAR	Estimated Proved Reserves Beginning of Year	*New Reserves Proved During Year	Crude Oil Production During Year	Estimated Proved Reserves at End of Year	Ratio of Reserves At End of Year to Year's Production (Year's Supply)	Net Increase or Decrease in Reserves During Year
Reserves Including Condensate						
1918	5,900,000,000	655,928,000	355,928,000	6,200,000,000	17.4	+ 300,000,000
1919	6,200,000,000	878,367,000	378,367,000	6,700,000,000	17.7	+ 500,000,000
1920	6,700,000,000	942,929,000	442,929,000	7,200,000,000	16.3	+ 500,000,000
1921	7,200,000,000	1,072,183,000	472,183,000	7,800,000,000	16.5	+ 600,000,000
1922	7,800,000,000	357,531,000	557,531,000	7,600,000,000	13.6	— 200,000,000
1923	7,600,000,000	732,407,000	732,407,000	7,600,000,000	10.4	.....
1924	7,600,000,000	613,940,000	713,940,000	7,500,000,000	10.5	— 100,000,000
1925	7,500,000,000	1,763,743,000	763,743,000	8,500,000,000	11.1	+1,000,000,000
1926	8,500,000,000	1,070,874,000	770,874,000	8,800,000,000	11.4	+ 300,000,000
1927	8,800,000,000	2,601,129,000	901,129,000	10,500,000,000	11.7	+1,700,000,000
1928	10,500,000,000	1,401,474,000	901,474,000	11,000,000,000	12.2	+ 500,000,000
1929	11,000,000,000	3,207,323,000	1,007,323,000	13,200,000,000	13.1	+2,200,000,000
1930	13,200,000,000	1,298,011,000	898,011,000	13,600,000,000	15.1	+ 400,000,000
1931	13,600,000,000	251,081,000	851,081,000	13,000,000,000	15.3	— 600,000,000
1932	13,000,000,000	85,159,000	785,159,000	12,300,000,000	15.7	— 700,000,000
1933	12,300,000,000	605,656,000	905,656,000	12,000,000,000	13.3	— 300,000,000
1934	12,000,000,000	1,085,065,000	908,065,000	12,177,000,000	13.4	+ 177,000,000
1935	12,177,000,000	1,219,596,000	996,596,000	12,400,000,000	12.4	+ 223,000,000
1936	12,400,000,000	1,763,087,000	1,099,687,000	13,063,400,000	11.9	+ 663,400,000
1937	13,063,400,000	3,723,028,000	1,279,160,000	15,507,268,000	12.1	+2,443,868,000
1938	15,507,268,000	3,055,233,000	1,214,355,000	17,348,146,000	14.3	+1,840,878,000
1939	17,348,146,000	2,399,828,000	1,264,962,000	18,483,012,000	14.6	+1,134,866,000
1940	18,483,012,000	1,894,717,000	1,353,214,000	19,024,515,000	14.1	+ 541,503,000
1941	19,024,515,000	1,967,009,000	1,402,228,000	19,589,296,000	14.0	+ 564,781,000
1942	19,589,296,000	1,880,142,000	1,386,645,000	20,082,793,000	14.5	+ 493,497,000
1943	20,082,793,000	1,486,972,000	1,505,613,000	20,064,152,000	13.3	— 18,641,000
1944	20,064,152,000	2,066,983,000	1,677,904,000	20,453,231,000	12.2	+ 389,079,000
1945	20,453,231,000	2,087,237,000	1,713,655,000	20,826,813,000	12.2	+ 614,125,000
Reserves of Crude Oil Only						
1945	19,784,530,000	1,870,971,000	1,713,655,000	19,941,846,000	11.6	+ 157,316,000
1946	19,941,846,000	2,665,653,000	1,733,939,000	20,873,560,000	12.0	+ 931,714,000
1947	20,873,560,000	2,470,232,000	1,856,107,000	21,487,685,000	11.6	+ 614,125,000

* In both new and older reservoirs and reflecting upward or downward revisions of earlier estimates based on additional information.
Source: Reserves from American Petroleum Institute and Production from Bureau of Mines.

greater than it was. By implication, drilling would have had to embrace about one third more well completions than it did.

New Estimates

The new estimates of API and AGA indicate that the total proved liquid hydrocarbon reserves in the U. S. as of December 31, 1947, amounted to 24,741,660,000 barels. That was 704,881,000 barrels more than the corresponding reserves of 24,036,779,000 barrels at the end of 1946. These figures include natural gas liquids as well as crude oil. Crude reserves were estimated at 21,487,685,000 barrels at the end of 1947, up 614,125,000 from the 20,873,560,000 barrels estimated at the end of 1946. Reserves of natural gas liquids, including condensate, natural gasoline, and liquefied petroleum gases, were estimated at 3,253,975,000 barrels December 31, 1947, up 90,756,000 from the 3,163,219,000 barrels at the end of 1946.

As in previous annual reports on reserves, API and AGA committees which made the estimates emphasized that their estimates refer solely to "proved" or blocked out reserves. They include only oil and natural gas liquids recoverable under existing economic and operating conditions. The estimations do not include crude oil in the unproved portions of partially developed fields; oil in untested prospects; oil that may be present in regions believed to be favorable; oil that becomes available by secondary-recovery methods; liquid fuels that may become available through chemical processing of natural gas; or synthetic fuels that may be made from coal, shale, or other materials.

Under the committees' definitions, proved reserves are both drilled and undrilled. The proved drilled reserves, in any pool, include the oil estimated to be recoverable by the production systems now in operation, whether primary or secondary, and from the area actually drilled up on the spacing pattern in vogue in that pool. The proved undrilled reserves, in any pool, include reserves under undrilled spacing units which are so close, and so related, to the drilled units that there is every reasonable probability that they will produce when drilled.

In the case of new discoveries, which are seldom fully developed in the first year and in fact for several years thereafter, said the committees, the estimates of proved reserves necessarily represent but a part of the reserves which ultimately may be assigned to the new reservoirs discovered each year. For a one-well field, where development has not yet gone beyond the discovery well, the area assigned as proved is usually small in regions of complex geological conditions, but may be larger where the geology is relatively simple. In a sparsely drilled field the area between wells is considered proved only if the information regarding the geology of the field and the productive horizon is adequate to assure that such area will produce when drilled. The total of new oil through discoveries estimated as proved in any given year is comparatively small, and the total of new oil through extensions is comparatively large. As knowledge of the factors affecting production and well performance becomes available, and as these factors are studied, reserves in older fields can be estimated with greater precision and revised accordingly. Therefore, the oil assigned to new discoveries, plus the oil proved through extensions, comprises the total quantity of the new proved reserves for the year.

The committees again stress the fact that the estimates of proved reserves cannot be used as a measure of the rate at which these reserves can be produced with or without physical waste. Oil cannot be produced from the permeable rocks in which it occurs at any desired rate, the committee points out, because the flow of oil through the pores of the oil-bearing rocks is definitely controlled by the physical factors of the reservoir.

TABLE 3

Estimated Proved Reserves of Natural-Gas Liquids in the United States

(Includes condensate, natural gasoline and liquefied petroleum gases)

(Barrels of 42 U. S. Gallons) (A.P.I.—A.G.A. Committees)

	Proved Reserves as of December 31, 1946 (1)	Changes in Proved Reserves Due to Extensions (New Natural-Gas Liquids) and Revisions During 1947 (2)	Proved Reserves in New Pools Discovered in 1947* (3)	Production During 1947 (4)	Proved Reserves as of December 31, 1947 (Columns 1+2+3 Less Column 4) (5)	Change in Reserves During 1947 (Column 5 Less Column 1) (6)
Alabama†	.....	.....	.....	.....	.....	.....
Arkansas	61,600,000	(—) 264,000	768,000	3,845,000	58,259,000	(—) 3,341,000
California	308,272,000	28,364,000	432,000	24,917,000	312,151,000	3,879,000
Colorado	2,377,000	5,565,000	.....	.....	7,942,000	5,565,000
Illinois	34,200,000	(—) 12,313,000	39,000	4,006,000	17,920,000	(—)16,280,000
Indiana	85,000	(—) 5,000	.....	15,000	65,000	(—) 20,000
Kansas	82,492,000	7,786,000	159,000	1,625,000	88,812,000	6,320,000
Kentucky	16,071,000	711,000	.....	1,438,000	15,344,000	(—) 727,000
Louisiana	419,396,000	54,192,000	9,267,000	20,041,000	462,814,000	43,418,000
Michigan	655,000	466,000	184,000	240,000	1,065,000	410,000
Mississippi	a53,233,000	4,220,000	1,796,000	590,000	58,659,000	5,426,000
Montana	8,534,000	(—) 7,038,000	.....	136,000	1,360,000	(—) 7,174,000
New Mexico	73,609,000	16,065,000	58,000	3,810,000	85,922,000	12,313,000
New York†	.....	.....	.....	.....	.....	.....
Ohio	1,714,000	189,000	.....	167,000	1,736,000	22,000
Oklahoma	68,317,000	83,986,000	17,952,000	15,252,000	155,003,000	86,686,000
Pennsylvania	2,309,000	242,000	.....	315,000	2,236,000	(—) 73,000
Texas	1,985,606,000	23,568,000	28,646,000	80,757,000	1,957,063,000	(—)28,543,000
West Virginia	19,285,000	1,713,000	.....	3,477,000	17,521,000	(—) 1,764,000
Wyoming	25,458,000	(—) 15,422,000	.....	136,000	9,900,000	(—)15,558,000
Miscellaneous‡	6,000	212,000	.....	15,000	203,000	197,000
Total U.S.	a3,163,219,000	192,237,000	59,301,000	160,782,000	3,253,975,000	90,756,000

* Only a limited area is assigned to each new discovery, even though the committee may believe that eventually a much larger area will produce, for, in this report, the concern is only with actually proved reserves.
† Included in Miscellaneous. ‡ Includes Alabama, Florida, New York and Utah. a Revised

TABLE 4

Estimated Proved Reserves of Liquid Hydrocarbons in the United States

(Barrels of 42 U. S. Gallons) (A.P.I.—A.G.A. Committees)

	Proved Reserves as of December 31, 1946 (1)	Changes in Proved Reserves Due to Extensions (New Oil) and Revisions During 1947 (2)	Proved Reserves in New Pools Discovered in 1947* (3)	Production During 1947 (4)	Proved Reserves as of December 31, 1947 (Columns 1+2+3 Less Column 4) (5)	Change in Reserves During 1947 (Column 5 Less Column 1) (6)
Alabama†	512,000	2,652,000	.....	405,000	2,759,000	2,247,000
Arkansas	328,658,000	56,221,000	2,055,000	31,767,000	355,167,000	26,509,000
California	3,601,763,000	349,645,000	13,787,000	358,081,000	3,607,114,000	5,351,000
Colorado	302,247,000	103,089,000	160,000	15,672,000	389,824,000	87,577,000
Illinois	385,464,000	50,151,000	8,892,000	71,226,000	373,281,000	(—)12,183,000
Indiana	44,155,000	7,502,000	1,580,000	7,157,000	46,080,000	1,925,000
Kansas	627,808,000	110,034,000	19,290,000	105,642,000	651,490,000	23,682,000
Kentucky	75,259,000	12,900,000	2,770,000	11,035,000	79,894,000	4,635,000
Louisiana	2,071,193,000	293,132,000	66,814,000	177,321,000	2,253,818,000	182,625,000
Michigan	69,832,000	8,602,000	8,946,000	16,601,000	70,779,000	947,000
Mississippi	323,454,000	72,554,000	1,820,000	35,492,000	362,336,000	38,882,000
Montana	112,780,000	9,758,000	2,665,000	9,181,000	116,022,000	3,242,000
Nebraska	875,000	205,000	.....	214,000	866,000	(—) 9,000
New Mexico	617,062,000	40,611,000	3,453,000	44,721,000	616,405,000	(—) 657,000
New York†	76,289,000	.....	.....	4,770,000	71,519,000	(—) 4,770,000
Ohio	30,934,000	3,581,000	.....	3,785,000	30,730,000	(—) 204,000
Oklahoma	966,503,000	198,443,000	100,254,000	157,207,000	1,107,993,000	141,490,000
Pennsylvania	99,810,000	38,178,000	.....	13,032,000	124,956,000	25,146,000
Texas	13,631,966,000	737,673,000	261,450,000	896,489,000	13,734,600,000	102,634,000
West Virginia	54,940,000	4,813,000	.....	6,140,000	53,613,000	(—) 1,327,000
Wyoming	614,816,000	108,491,000	10,795,000	44,891,000	689,211,000	74,395,000
Miscellaneous‡	459,000	3,142,000	.....	398,000	3,203,000	2,744,000
Total U.S.	24,036,779,000	2,211,377,000	504,731,000	2,011,227,000	24,741,660,000	704,881,000

* Only a limited area is assigned to each new discovery, even though the committee may believe that eventually a much larger area will produce, for, in this report, the concern is only with actually proved reserves.
† Crude oil only, natural gas liquids not separable from miscellaneous grouping in that table.
‡ Includes Alabama and New York natural gas liquids; Missouri, Tennessee and Virginia crude; Florida and Utah crude and natural gas liquids.

TABLE 5
Summary of Committee's Annual Reports Covering Period 1937-1947
(Barrels of 42 U. S. Gallons)

Proved Reserves as Reported Prior to 1946

YEAR	NEW OIL FOUND DURING YEAR: Through Revisions of Previous Estimates and Extensions to Known Fields	NEW OIL FOUND DURING YEAR: Through New Pools Discovered During Year	Total Through New Discoveries, Extensions and Revisions	Production During Year	Estimated Proved Reserves as of End of Year	Increase Over Previous Year
1936	.....	.....	.....	.....	13,063,400,000	.....
1937	2,792,790,000	928,742,000	3,721,532,000	1,277,664,000	15,507,268,000	2,433,868,000
1938	2,243,571,000	810,493,000	3,054,064,000	1,213,186,000	17,348,146,000	1,840,878,000
1939	2,058,455,000	340,667,000	2,399,122,000	1,264,256,000	18,483,012,000	1,134,866,000
1940	1,607,012,000	286,338,000	1,893,350,000	1,351,847,000	19,024,515,000	541,503,000
1941	1,538,989,000	429,974,000	1,968,963,000	1,404,182,000	19,589,296,000	564,781,000
1942	1,618,925,000	260,051,000	1,878,976,000	1,385,479,000	20,082,793,000	493,497,000
1943	1,202,368,000	282,418,000	1,484,786,000	1,503,427,000	20,064,152,000	(—)18,641,000
1944	1,556,192,000	511,308,000	2,067,500,000	1,678,421,000	20,453,231,000	389,079,000
1945	1,690,315,000	419,984,000	2,110,299,000	1,736,717,000	20,826,813,000	373,582,000
December 31, 1945, Estimated Proved Reserves of Crude Oil only (see note below)					19,941,846,000	

Note: Up to and including its figures on Proved Reserves of Petroleum as of Dec. 31, 1945, the Committee combined under that heading the estimated proved reserves of cycle-plant and lease condensate. As of Dec. 31, 1945, the reserves so included totaled 884,967,000 bbl. and as of Dec. 31, 1944 there were 668,701,000 bbl. included. Beginning with the report of Dec. 31, 1946, the figures in this table show crude oil and natural gas liquids. It is to be remembered that, previous to Dec. 31, 1946, not all classes of natural gas liquids were included. For this reason the totals for crude oil and natural gas liquids, as herewith recorded for 1946 and 1947, are not comparable with the figures recorded for years prior to 1946.

Proved Reserves as Reported for 1946 and Thereafter

Crude Oil Only						
1946	2,413,628,000	244,434,000	2,658,062,000	1,726,348,000	20,873,560,000	931,714,000
1947	2,019,140,000	445,430,000	2,464,570,000	1,850,445,000	21,487,685,000	614,125,000
Natural Gas Liquids Only						
1946	(..... This detail not available for 1946 .....)				3,163,219,000	.....
1947	192,237,000	59,301,000	251,538,000	160,782,000	3,253,975,000	90,756,000
Total Liquid Hydrocarbons						
1946	(..... This detail not available for 1946 .....)				24,036,779,000	.....
1947	2,211,377,000	504,731,000	2,716,108,000	2,011,227,000	24,741,660,000	704,881,000

As a matter of fact, today's known oil can be recovered only over a period of many years and at gradually declining annual rates. This has been widely demonstrated by past performance under all kinds of operating conditions.

World Supply-Demand Prospects

■ CONTINUED FROM PAGE 42

000 barrels a day in each of the next four years, a slightly more liberal estimate.

By 1951, estimates based on the present trend of production and consumption in the U. S., put net oil imports into this country as high as ten times the 1948 forecast of 167 million barrels of crude and products. This would make the U. S. probably the greatest oil-importing nation in the world. In 1951 exports to Europe are expected to decline to about 15 million barrels as compared with a forecast of 149 million barrels this year.

Bauer offers this summary of 1951 prospects;

"Western Hemisphere demand for crude and products is expected to increase 1 million barrels a day in four years, or 16 percent. The anticipated increase in crude production is less than 700,000 barrels a day, or about 10 percent. Refinery runs may be increased over 900,000 barrels a day, or 15 percent. The net export balance of crude and products decreases from 694,000 barrels a day in 1947 to 392,000 in 1951.

"In the Eastern Hemisphere, including Russia, demands are estimated to increase nearly a million barrels a day, or 43 percent. Production, on the other hand, increases 1,276,000 barrels a day, or 81 percent."

Many industry economists believe that the new surveys projected, especially the worldwide investigation to be conducted by the API, will tend to discount Middle East production by 1951, perhaps by as much as 50 percent of its now contemplated increment, because of the delay in the pipe line program and short tanker fleet. Such an analysis might reflect in still further paring down of Marshall Plan quotas and the continued dependence of Europe on Caribbean sources. In such an event the Caribbean area would be the largest producing region of the world outside the U. S., but might fail to supply European requirements by as much as a million barrels a day, depending on what percent of its exports went to the U. S.

These more pessimistic forecasters (who may prove to be the more realistic) then see a continuing tight supply situation world-wide through 1951, including the U. S., with a later balance, about 1955-1957, when Middle East oil is in full flow westward.

The still more pessimistic observers (extremely few in number now) regard the Middle East as a lost source of petroleum for the Western World, and see no possibility of world balance for perhaps 15 years, during which time development of Mexico's reserves, or other Western Hemisphere sources, can be achieved—supplemented, perhaps, by a growing synthetics industry.

Gas Reserves

■ CONTINUED FROM PAGE 44

indicated declines in years' supply of natural gas and natural gas liquids in reserves are not matters for alarm. No early shortages of these resources are indicated, for in spite of only small increases during the year, the reserves still are comparatively large. Both are still relatively more plentiful than crude.

Checking into the accompanying estimates of natural gas reserves by the American Gas Association, it is found that the total reserves of 165,926,914,000,000 cubic feet as of December 31, 1947, were equivalent to 29.5 years' supply on the basis of the net production of 5,629,811,000,000 cubic feet in 1947. (Net production indicates gross withdrawals less gas reinjected into the underground reservoirs.) While this was still a comfortable ratio, it was considerably lower than that of a year previously. The estimated reserves of 160,575,901,000,000 cubic feet as of December 31, 1946, were equivalent to 32.5 years' supply on the basis of the net production of 4,942,617,000,000 cubic feet in 1946.

This sharp drop in years' supply of natural gas reserves was primarily the result of an extraordinary increase in demand and production, occurring while reserves were being expanded only moderately or normally. The net production of 1947 was 13.9 percent greater than that of 1946. To keep up with such an increase in production over a period of years, the backlog of proved reserves would have to be doubled within about seven years in addition to proving up in the meantime enough new reserves to compensate for the large and sharply increasing current production. Instead of increasing 13.9 percent in 1947 as did production, the proved natural gas reserves showed a net increase, after production, of only 3.3 percent.

Judging, by results in 1947, if natural gas shows continuing sharp increases in demand and production, it seems quite likely that there will be a further steady reduction of the years' supply of reserves available.

The present 29.5 years' supply of natural gas is large in comparison with crude oil reserves, which have ranged over many years from ten to 20 years' supply and which have been around 12 years' supply in recent years. It should be a long time before natural gas could become relatively no more plentiful than crude.

Nevertheless, the current trend toward fewer years' supply of natural gas in reserve has some highly significant implications. In the first place, a continuing improvement in the market for natural gas is indicated, with better prices at the well strongly suggested for the future. Another obvious implication is

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2½	35 38 40	36–4 39–4 41–4	36–6 39–6 41–6	32 35 37	4½ Reg. 6⅝ Reg.	5½* 7⅛	2⅝ Reg. 2⅞ I.F.	3½ 3⅝	1 11/16 1¾	3 3/32	2½	2 5/16	5/16	3⅜	.165 .327
3	35 38 40	36–4 39–4 41–4	36–6 39–6 41–6	32 35 37	4½ Reg. 6⅝ Reg.	5½* 7⅛	2⅞ Reg. 3⅛ I.F.	3⅝ 4⅛	1⅞ 2	3 13/16	3	2 13/16	⅜	4⅛	.165 .327
3½	35 38 40	36–4 39–4 41–4	36–6 39–6 41–6	32 35 37	4½ Reg. 6⅝ Reg.	5½* 7⅛	3½ Reg. 3⅝ F.H. 3½ I.F.	4⅛ 4⅝	1½ 2 5/16	3 15/32	3½	3 19/32	½	4⅝	.165 .327
4¼	35 38 40 51 54	36–4 39–4 41–4 55–4	36–6 39–6 41–6 55–6	32 35 37 51	4½ Reg. 6⅝ Reg.	5½* 7⅛	4½ Reg. 4⅝ F.H. 4½ I.F.	5½* 5⅞ 6⅛	2½ 2⅝ 2¾	5 9/16	4¼	4 19/32	½	5⅜	.165 .327
5¼	38 40 54	39–4 41–4 55–4	39–6 41–6 55–6	35 37 51	6⅝ Reg.	7⅛	5½ Reg. 5⅝ F.H. 5½ I.F.	6⅝ 7⅛	2⅝ 3⅛ 3¼	6 27/32	5¼	5 5/16	⅝	6⅝	.165 .327
6	38 40 54	39–4 41–4 55–4	39–6 41–6 55–6	35 37 51	6⅝ Reg.	7⅛	6⅝ Reg. 6⅞ F.H.	7⅛ 7⅝	3½ 3⅝	7 7/8	6	6 3/16	¾	8	.327

Sizes shown in RED are A.P.I. standard.
* Alternate 5¾ inches O.D.—180 cu. ft. per lineal ft
† Volume based on largest diameter of kelly

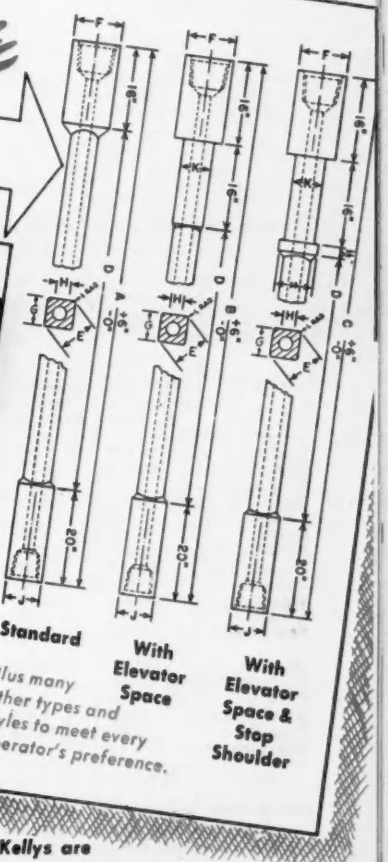

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TABLE 1

Summary of U. S. Reserves of Natural Gas

(See Table 3 for Data by States.)

TRILLIONS OF CUBIC FEET

Total proved reserves as of December 31, 1946	160.58
Extensions, and revision of previous estimate	7.57
New reserves discovered in 1947	3.41
Total proved reserves added in 1947	10.98
Total proved reserves as of December 31, 1946, and new proved reserves added in 1947	171.56
Deduct production during 1947	5.63
Total proved reserves of natural gas as of December 31, 1947	165.93

TABLE 2

Summary of U. S. Reserves of Natural Gas Liquids, Including Condensate, Natural Gasoline, and Liquefied Petroleum Gases

(See Table 4 for Data by States.)

MILLIONS OF BARRELS

Total proved reserves as of December 31, 1946	3,163.2
Extensions, and revisions of previous estimate,	192.2
New reserves discovered in 1947	59.3
Total proved reserves added in 1947	251.5
Total proved reserves as of December 31, 1946, and new proved reserves added in 1947	3,414.7
Deduct production during 1947	160.8
Total proved reserves of natural gas liquids as of December 31, 1947	3,253.9

TABLE 3

Estimated Proved Recoverable Reserves of Natural Gas in the United States

(Millions of Cubic Feet—14.65 psi. Absolute Base)

	Reserves as of December 31, 1946	CHANGES IN RESERVES DURING 1947[2]			RESERVES AS OF DECEMBER 31, 1947[2]			
		Extensions and Revisions	Discoveries of New Fields and New Pools in Old Fields	Net Production[3]	Total	Non-Assoc.[4]	Associated[5]	Dissolved[6]
Alabama	97	503	.....	76	524	.....	.....	524
Arkansas	871,662	50,926	29,940	62,379	890,149	455,278	155,408	279,463
California	11,126,301	(—)460,302	58,251	559,894	10,164,356	3,088,452	2,951,684	4,124,220
Colorado	315,763	11,906	15,238	11,041	331,866	174,939	40,771	116,156
Illinois	268,000	(—) 5,832	7,770	48,807	221,131	5,526	25,000	190,605
Indiana	17,000	(—) 1,000	.....	3,000	13,000	4,000	4,000	5,000
Kansas	13,680,844	1,090,607	24,877	239,412	14,556,916	14,155,560	212,612	188,744
Kentucky	1,386,000	88,480	.....	95,000	1,379,480	1,299,480	.....	80,000
Louisiana	22,411,511	1,164,711	590,878	685,867	23,481,233	18,697,916	3,264,720	1,518,597
Michigan	131,000	38,008	36,881	37,420	168,469	124,339	.....	44,130
Mississippi	2,370,513	65,536	71,877	55,166	2,452,760	1,831,826	390,222	230,712
Missouri	55	.....	.....	1	54	54	.....	.....
Montana	853,401	(—)165,947	49,255	36,199	700,510	469,515	200,245	30,750
Nebraska	1	809	.....	160	650	.....	.....	650
New Mexico	5,904,786	6,293	311,365	232,161	5,990,283	3,126,494	2,111,027	752,762
New York	69,900	1,000	.....	6,000	64,900	64,100	.....	800
Ohio	614,000	71,200	.....	74,000	611,200	571,200	.....	40,000
Oklahoma	10,735,845	272,040	967,265	624,286	11,350,864	7,752,994	1,896,068	1,701,802
Pennsylvania	503,000	56,063	.....	76,000	483,063	435,313	.....	47,750
Texas	86,363,459	4,960,772	1,205,496	2,504,161	90,025,566	64,971,473	16,308,314	8,745,779
West Virginia	1,840,000	163,735	.....	223,000	1,780,735	1,685,235	.....	95,500
Wyoming	1,035,597	164,536	41,077	49,422	1,191,788	771,115	130,448	290,225
Miscellaneous[1]	77,166	(—) 3,390	.....	6,359	67,417	66,670	.....	747
Total	160,575,901	7,570,654	3,410,170	5,629,811	165,926,914	119,751,479	27,690,519	18,484,916

[1] Includes Utah and Florida. [2] Excludes shrinkage caused by natural gas liquids recovery. [3] Net production equals gross withdrawals less gas reinjected into underground reservoirs. [4] Non-associated gas is free gas not in contact with crude oil in the reservoir. [5] Associated gas is free gas in contact with crude oil in the reservoir. [6] Dissolved gas is gas in solution with crude oil in the reservoir.

TABLE 4

Estimated Proved Recoverable Reserves of Natural Gas Liquids[1] in the United States

(THOUSANDS OF BARRELS)

	Reserves as of December 31, 1946	CHANGES IN RESERVES DURING 1947			RESERVES AS OF DECEMBER 31, 1947			
		Extensions and Revisions	Discoveries of New Fields and New Pools in Old Fields	Net Production	Total	Non-Assoc.	Associated	Dissolved
Arkansas	61,600	(—) 264	768	3,845	58,259	37,638	7,864	12,757
California	308,272	28,364	432	24,917	312,151	36,900	115,605	159,646
Colorado	2,377	5,565	.....	.....	7,942	.....	1,482	6,460
Illinois	34,200	(—) 12,313	39	4,006	17,920	28	125	17,767
Indiana	55	(—) 5	.....	15	65	20	20	25
Kansas	82,492	7,786	159	1,625	88,812	85,315	2,553	944
Kentucky	16,071	711	.....	1,438	15,344	[2]15,344	.....	.....
Louisiana	419,396	54,192	9,267	20,041	462,814	355,903	91,725	15,186
Michigan	655	466	184	240	1,065	624	.....	441
Mississippi	[3]53,233	4,220	1,796	590	58,659	25,611	30,741	2,307
Montana	8,534	(—) 7,038	.....	136	1,360	.....	.....	1,360
New Mexico	73,609	16,065	58	3,810	85,922	26,414	30,443	29,065
Ohio	1,714	189	.....	167	1,736	[2]1,736	.....	.....
Oklahoma	68,317	83,986	17,952	15,252	155,003	61,464	36,464	57,075
Pennsylvania	2,309	242	.....	315	2,236	[2]2,236	.....	.....
Texas	1,985,606	23,568	28,646	80,757	1,957,063	1,259,270	275,582	422,211
West Virginia	19,285	1,713	.....	3,477	17,521	[2]17,521	.....	.....
Wyoming	25,458	(—) 15,422	.....	136	9,900	1,900	.....	8,000
Miscellaneous[4]	6	212	.....	15	203	[2]203	.....	.....
Total	[3]3,163,219	192,237	59,301	160,782	3,253,975	1,928,127	592,604	733,244

[1] Includes condensate, natural gasoline, and liquefied petroleum gases. [2] Not allocated by types, but occurring principally in column shown. [3] Revised. [4] Includes Alabama, Florida, New York and Utah.

that natural gas reserves do not justify too much enthusiasm over currently proposed synthetic plants for making natural gas into liquid fuels.

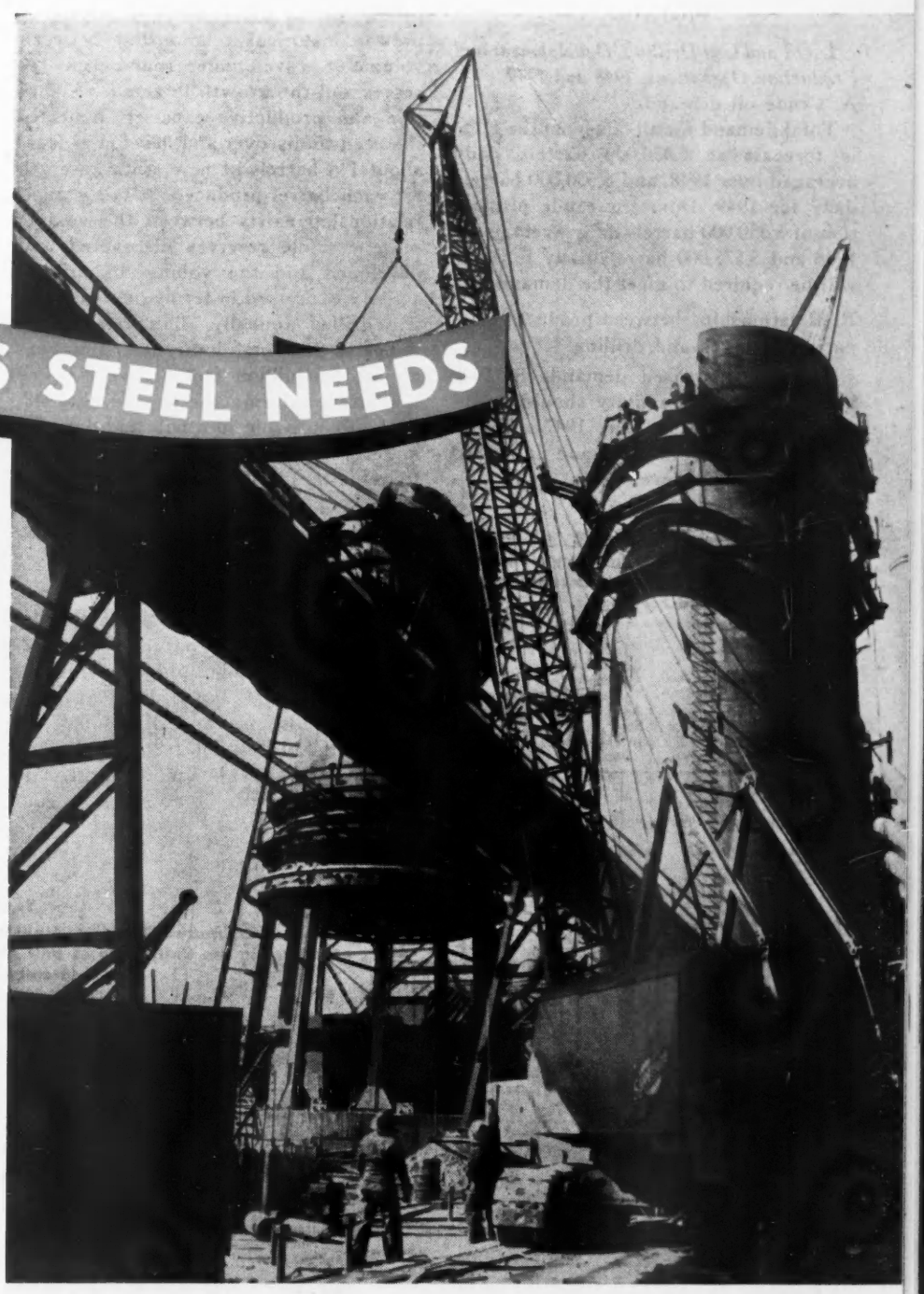
Results in 1947 in proving up new reserves of natural gas liquids were quite similar to those in blocking out natural gas reserves. Reserves of natural gas liquids proved up in 1947 exceeded net production for the year to afford a small net gain in reserves. But the reserves would have had to show a much larger net increase than they did to prevent a decline in years' supply of reserves.

The year's record as regards reserves of natural gas liquids is presented herewith, as estimated jointly by the American Gas Association and the API. The data include condensate, natural gasoline, and liquefied petroleum gases. The estimated reserves of 3,253,975,000 barrels as of December 31, 1947, were equivalent to 20.2 years' supply on the basis of the net production of 160,782,000 barrels in 1947. The estimated reserves of 3,353,887,000 barrels as of December 31, 1946, represented 25.9 years' supply on the basis of the net production of 129,262,000 barrels in 1946. The key to this sharp drop in years' supply is the phenomenal increase in production, which was 24.4 percent greater in 1947 than in 1946. On this basis, reserves would have to be doubled within four years in addition to supplying current needs in order to prevent decline in reserves in terms of years' supply. Now down to 20.2 years' supply, the reserves of natural gas liquids are no more plentiful than crude oil has been at times in the past. The trend would not have to continue long to put these liquids on about the same basis as crude oil.

AGA Estimates Explained

In making public its annual estimates on reserves, herewith published, the American Gas Association stated that the procedures followed in arriving at and assembling the reserve figures were the same as those used in past reports. Proved reserves may be in either the drilled or undrilled portion of a given field. Where the undrilled areas are considered proved, they are so related to the developed acreage and to the known field geology and structure that their productive ability is considered assured. Recoverable reserves of natural gas are defined by the American Gas Association as the reserves estimated to be producible under present operating practices. Since the estimates are made by fields, the recovery factors or abandonment pressures used in the calculations were determined by the operating conditions of each individual field. Proved recoverable reserves of natural gas liquids are those contained in recoverable gas reserves and extractable by methods now used in the respective fields.

INDUSTRY'S STEEL NEEDS



The steel industry has under way a gigantic modernization and expansion program designed to meet the needs of the oil industry and others.

FOR THE first time in history a complete and detailed survey has been made covering the steel requirements of the entire American petroleum industry and its related activities, both domestic and foreign. The voluminous report showing the industry's steel needs is here briefly summarized. Also presented here are several salient tables selected from among the many that are embodied in the report.

Within the next 18 months the petroleum industry will need an estimated 15,571,500 tons of steel mill products to prevent shortages of petroleum products in the next few years, it is stated in the report. This total was arrived at by estimating demand for petroleum products and by determining, from past experience, how much steel will be required by the industry if it is to be able to supply those oils.

The report was prepared by oil industry men serving on the committee on petroleum industry steel requirements of the National Petroleum Council. The report was submitted to the Departments of Interior and Commerce, for their information in administration of the "Taft" law, authorizing allocations of scarce goods on voluntary basis.

TO MEET estimated petroleum demands, the total steel requirements both direct and indirect for the American petroleum industry at home and abroad, for the 18-month period from April 1, 1948, to September 30, 1949, amount to 15,571,500 tons, or at the rate of 10,381,000 tons per year. The steel requirement figures were released March 17 by the National Petroleum Council's committee on petroleum industry steel requirements in a 100-page detailed report covering all phases of the industry.

Table 1 is a summary of the committee's findings as to the industry's requirements of steel mill products exclusive of castings and forgings.

The estimates were prepared at the request of Max W. Ball, director of the Oil and Gas Division of the Department of the Interior for the information of the Interior and Commerce Departments in connection with their studies under the "Taft" law. The report is broken down for the following functional divisions of the oil industry: (1) oil and gas production; (2) oil transportation; (3) refining; (4) marketing; (5) natural gas transmission; and (6) foreign operations (U. S.-owned at least 50 percent).

The steel requirements were computed as necessary to supply estimates of total U. S. demand for petroleum, including exports, as shown in Table 3.

Following is a resume of the reports of the six subcommittees of the steel

committee, covering the sectors of the petroleum industry:

Production

1. Oil and Gas Drilling, Development and Production Operations, 1948 and 1949.

A. Crude oil demand.

Total demand for all oils from the U. S. is forecast at 6,250,000 barrels daily averaged over 1948, and 6,550,000 barrels daily for 1949. Domestic crude production of 5,350,000 barrels daily average for 1948 and 5,575,000 barrels daily for 1949 will be required to meet the demands.

B. Relationships between productive capacity, reserves and drilling.

To meet increased demands in 1948 and 1949, drilling activity should be increased considerably over 1947 and preceding years. Continued and increased exploratory and development drilling is necessary to discover and develop the additional new crude reserves and productive capacity to offset the declining production of older fields. Analysis of prewar historical relationship between volume of proved underground crude reserves and the growth in actual production and productive capacity, indicates the need to discover and develop at least about 1⅔ barrels of new crude reserves for each barrel produced. A fairly good relationship exists between the volume of new crude reserves discovered and developed and the volume of drilling activity expressed in terms of total footage drilled annually. This relationship indicates that total domestic drilling was about 18.5 million feet per year below that needed during the war years, 1942-1945, to provide normal additions to underground crude reserves in relation to actual crude production during those years.

1948-49 Program

C. Drilling program.

Based on these considerations, and considering that one-fourth of the deficiency in drilling during the years 1942-1945 should be made up during this and succeeding years, the drilling program for 1948 calls for the drilling of 37,600 wells and 130.5 million feet of hole; and 38,300 wells and 134 million footage in 1949.

D. Steel requirements for oil and gas drilling, development and production operations.

To carry out these drilling programs, large quantities of steel will be required. Oil country tubular goods and line pipe account for the major tonnage, but large quantities of plate and sheet, bars, structural shapes, etc., are also needed. Petroleum operators' and petroleum equipment manufacturers' stocks of these materials are depleted to below efficient working levels, and hence the entire requirements, except for minor salvage, will have to be met from new supplies.

New supply of oil country tubular goods has averaged close to 11.2 tons per 1000 feet drilled over the years. Total new steel requirements of all classes of mill products for the 1948-1949 drilling programs are estimated at 15.45 tons per 1000 feet drilled, or 52.8 tons per well based on expected well depths of 3475 feet average for 1948. This includes casing and tubing (plus line pipe often used for this purpose in shallow wells), pumping units and drivers, sucker rods, valves and fittings, flow lines, oil and gas separators, heaters, treaters and lease tankage.

Steel and steel products are not being received currently by petroleum operators or by manufacturers of oil field equipment in sufficient quantities to en-

TABLE 1

Summary of Petroleum Industry's Requirements of Steel Mill Products Except Castings and Forgings

	Total Requirements 18 Month Period April 1, 1948-Sept. 30, 1949 in Thousands of Tons	Requirements Expressed in Thousands of Tons per Year
(1.) Steel Requirements for following activities of domestic petroleum Industry;		
Oil and Gas Production:		
Oil and Gas	3,654.0	2,436.0
Nat. Gaso., etc	304.6	203.1
Sub-Total	3,958.6	2,639.1
Oil Pipe Lines	1,646.4	1,097.5
Refining	1,363.8	909.1
Marketing:		
Terminals, bulk plants, & Service Stations	611.9	408.0
L. P. G. plant facilities	127.2	84.8
Sub-Total	739.1	492.8
TOTAL	7,707.9	5,138.5
(2.) Requirements nat. gas transmission up to city gate:		
Natural Gas	2,191.9	1,461.4
(3.) Requirements for packaging, other transportation, and home storage in U. S.:		
Containers	1,496.6	997.8
Transportation (Other than Pipe Line):		
Tankers	370.9	247.2
Barges	319.1	212.7
Tank Cars	324.3	216.2
Truck Tanks	106.1	70.7
Sub-Total	1,120.4	746.8
Farm & Home Storage:		
Oil	558.8	372.5
L. P. G	781.5	521.0
Sub-Total	1,340.3	893.5
(4.) Requirements for American petroleum industry abroad:		
Foreign (U. S. Owned)	1,714.4	1,143.0
(5.) Total of all direct and allied steel requirements of American petroleum industry, domestic and foreign, as itemized above:		
GRAND TOTAL	15,571.5	10,381.0

TABLE 2

Summary of Estimated Quarterly Steel Requirements for the American Petroleum Industry in the United States and Abroad in 18 Months, April 1, 1948, to September 30, 1949

(Thousands of Short Tons)

	1948			1949		
	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q
DOMESTIC PETROLEUM INDUSTRY USE						
Oil and Gas Production:						
Oil and Gas	552.9	640.7	667.4	528.6	597.8	667.1
Natural Gasoline, etc	60.1	73.9	53.6	39.9	39.9	37.2
Sub-Total	613.0	714.6	721.0	568.5	637.7	704.3
Oil Transportation:						
Pipe Lines	226.7	347.3	182.1	258.7	297.9	333.9
Tankers	61.8	61.8	61.8	61.8	61.8	61.8
Barges	58.2	58.2	58.2	58.2	58.2	58.2
Tank Cars	54.1	54.1	54.1	54.1	54.1	54.1
Truck Tanks	8.3	8.3	8.3	8.3	8.3	8.3
Sub-Total	409.1	529.7	364.5	441.1	480.3	516.3
Refining:	180.6	240.4	253.2	249.6	255.8	184.4
Marketing:						
Plant Facilities	103.7	103.7	103.7	102.5	102.5	102.5
Containers	263.0	263.0	175.3	198.8	298.3	298.3
Consumer Storage	93.2	93.2	93.2	93.2	93.2	93.2
L. P. G.	152.9	152.9	152.9	153.0	153.0	153.0
Sub-Total	612.8	612.8	525.1	547.5	647.0	647.0
Total Domestic Petroleum Industry Use	1,815.5	2,097.5	1,863.8	1,806.7	2,020.8	2,052.0
Natural Gas Transmission	365.7	365.6	365.3	365.3	365.1	364.9
Total Domestic Requirements	2,181.2	2,463.1	2,229.1	2,172.0	2,385.9	2,416.9
Foreign Operations (U.S. Owned):						
Western Hemisphere	130.1	132.8	129.6	115.2	110.3	108.9
Eastern Hemisphere	150.3	161.1	162.0	150.4	172.2	200.4
Sub-Total	280.4	293.9	291.6	265.6	282.5	309.3
GRAND TOTAL—Requirements	2,461.6	2,757.0	2,520.7	2,437.6	2,668.4	2,726.2

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- Proved financial responsibility.
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able accomplishment of the necessary drilling program.

2. Natural gasoline, cycling and pressure maintenance plants.

Estimates were obtained by contacting all known construction companies now building plants and several large oil companies who engineer and design their own plants. To these tonnage reports 10 percent was added to cover plants not contacted and 4 percent for maintenance steel for the period. Thus, total steel requirements for the period are 359,322 tons. The amount is based on the actual construction of 62 natural gasoline, recycling and pressure maintenance projects, either now under construction or planned and authorized during the period in nine states. In the 62 plants are included five pressure maintenance plants. The capacity included covers handling of 3498 Mmfc from which it is estimated that 51,250 barrels daily gasoline production will be recovered, and 75,290 barrels additional liquefied petroleum gas, and that the pressure maintenance plants will permit production of 12,850 barrels daily additional from crude.

Natural gasoline and liquefied petroleum gas production is estimated at 46 million barrels additional per year, an increase of 45.4 percent over 1947 production. Of the increased porduction, 59.7 percent is for recovery of additional liquefied petroleum gas. The figures do not include any of the 10 percent increase in steel used for plants in progress that have not been contacted.

Transportation

Total steel requirements for domestic crude oil and products pipe lines are 1,617,103 tons, based on data furnished by 79 companies. In addition, requirement estimates included by four companies in their requirement needs for refineries totaled 29,429 tons, giving a grand total of 1,646,532 tons for the 83 companies.

Steel requirements for tankers under construction and ordered for delivery during 1948 and 1949, total 370,890 tons, of which amount 175,000 tons are for repairs and maintenance, and 195,890 tons are for new construction. Another 150,000 tons are allowed for construction contracts that may be placed in U. S. yards. A tanker is defined as a petroleum-carrying vessel of 3000 tons deadweight or more.

Steel requirements for barges (vessels of less than 3000 tons deadweight) total 349,086 tons.

Steel requirements for tank cars total 324,360 tons, covering total capacity of the two companies which build such cars.

Steel requirements for tank trucks with carrying capacity of 2000 gallons or more total 50,040 tons for the tanks only, with no allowance for the steel required in the structural shapes, tubular goods, forgings or castings of these tanks. An estimate of 41,184 tons of steel is included for carbon steel and alloy steel required for trucks and tractors.

Refining

Steel requirements actually estimated and projected for additional refining capacity will amount to 1,363,966 tons of steel mill products for the total period. By quarters this total will be needed as follows: In 1948 a total of 180,596 tons of steel in the second quarter, 240,383 tons in the third quarter, and 253,154 tons in the fourth quarter; in 1949 a total of 249,606 tons in the first quarter, 255,764 tons in the second quarter, and 184,463 tons in the third quarter; total for the six quarters or 18 months being 1,363,966 tons of steel.

Marketing

Steel requirements for the marketing sector of the petroleum industry were computed on the following basis:

1. Essential expansion, replacement, and maintenance of: A. Terminals (1); B. blending, compounding, and packaging plants (1); C. motor transport (2).

2. Essential extension, replacement, and maintenance of: A. bulk plants; B. service stations.

3. Packages necessary for distribution of essential petroleum products.

4. Replace, maintain, and provide additional essential: A. farm storage tanks; B. LPG Consumer storage tanks; C. residential, industrial, and commercial heating oil storage tanks.

For all categories of the marketing sector, 226,480 tons of steel are estimated as required by the marketing sector of the industry through 1948 and 225,035 tons for the three quarters of 1949.

Natural Gas

Steel requirements for the natural gas industry for the period are put at 2,139,000 tons of pipe, of which 1,720,000 tons is 16-inch diameter or larger. For uses of steel other than pipe, the natural gas industry's requirements are estimated at 78,400 tons.

Foreign Operations

Steel requirements covering foreign operations of the oil industry are totaled for all companies whose ownership is predominantly American, even though the company be a foreign corporation. Total steel requirements for both hemispheres for the period are put at 1,723,642 tons, of which amount 996,483 tons represents operations in the Eastern hemisphere, and 727,159 tons in the Western hemisphere.

TABLE 3

Estimated Total U. S. Demand for Petroleum, Including Exports

YEAR	Total Demand (Barrels per Day)
1948	6,250,000
1949	6,550,000
1950	6,800,000

TABLE 4

Petroleum Demand and Supply Forecast, United States
(Thousands of Barrels Daily)

	1946	1947	1948	1949	1950
Demand—All Oils:					
Domestic	4,907	5,451	5,825	6,150	6,400
Export	414	458	425	400	400
Total Demand	5,321	5,909	6,250*	6,550*	6,800*
Supply:					
Domestic Crude Oil Production	4,749	5,077	5,350	5,575	5,760
Gasoline and Cycling Plant Production	315	360	400	425	440
Benzol Production	6	2	2	1	1
Imports—All Oils	370	432	500	550	600
Total	5,440	5,871	6,252	6,551	6,801
Stock Changes—All Oils	+119	−38	+2	+1	+1

* From Oil and Gas Division, U. S. Department of Interior.

TABLE 5

Forecast of Domestic Drilling and Reserves Development Required to Meet Anticipated Crude Oil Demand

	1948	1949
*Forecast of Required Domestic Crude Oil Production, Barrels Daily	5,350,000	5,575,000
†New Crude Oil Reserves Required to be Developed to Support Required Production, Million Barrels	3,280	3,420
‡Drilling Footage Required to Develop Necessary New Reserves, Million Feet:		
1st Quarter	28.2	28.7
2nd Quarter	30.4	32.7
3rd Quarter	35.3	36.8
4th Quarter	36.6	35.8
Total for Year	130.5	134.0
Estimated Average Well Depth, Ft.	3,475	3,500
Required Domestic Wells to be Drilled:		
1st Quarter	8,020	8,080
2nd Quarter	8,700	9,280
3rd Quarter	10,440	10,800
4th Quarter	10,440	10,140
Total for Year	37,600	38,300

* See Table 4.

† Based on historical relationship between actual Crude Oil Production and Proved Reserves, it is indicated that 1.68 barrels of new reserves should be developed for each barrel produced in order to provide sufficient sustained productive capacity to meet forecasted increasing demands.

‡ Based on historical relationship between Footage Drilled and resulting Additions to Proved Crude Oil Reserves, including 18.5 million feet per year to make up for ¼ of deficiency in Drilling during war years 1942-1945, inclusive.

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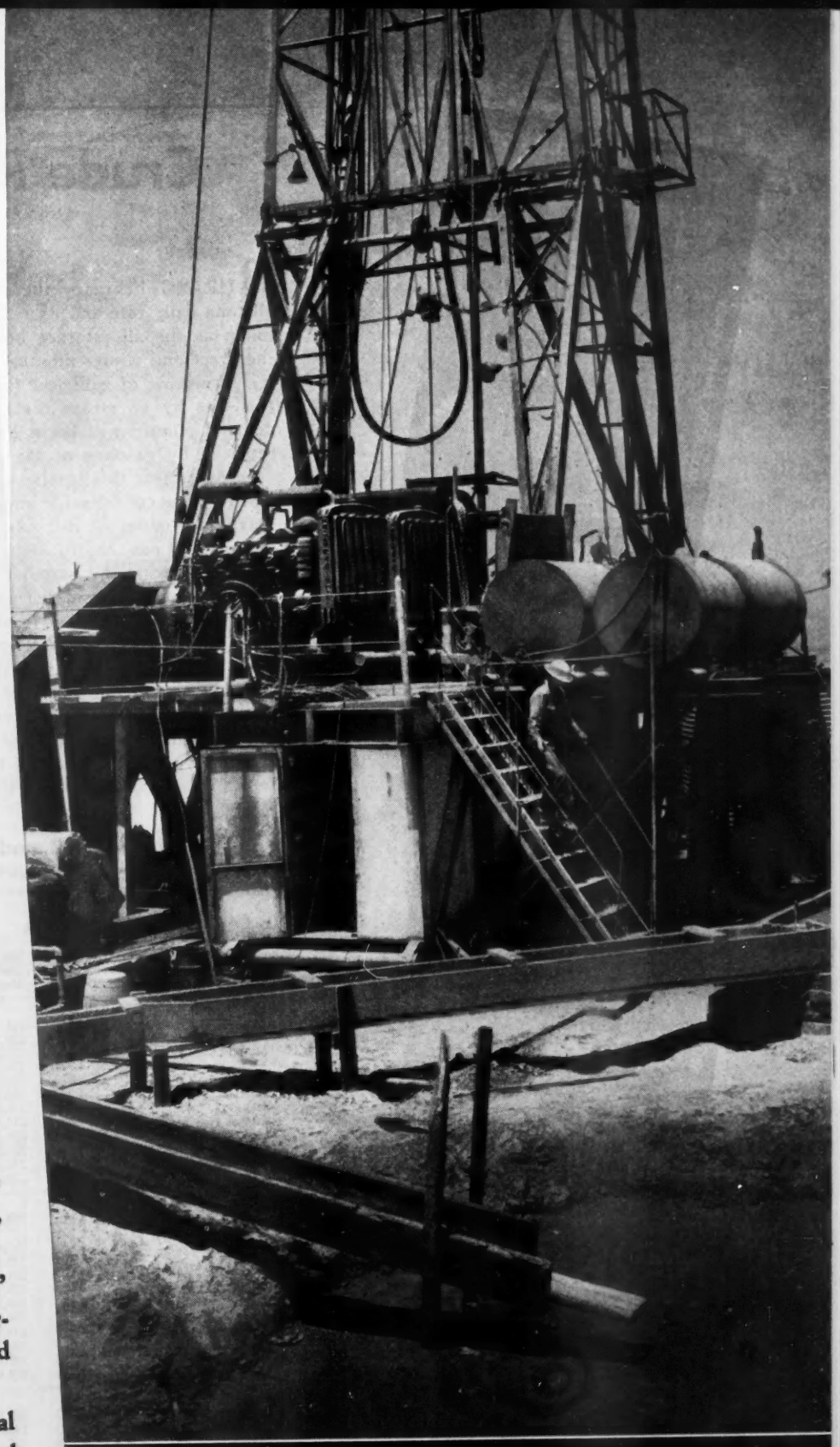

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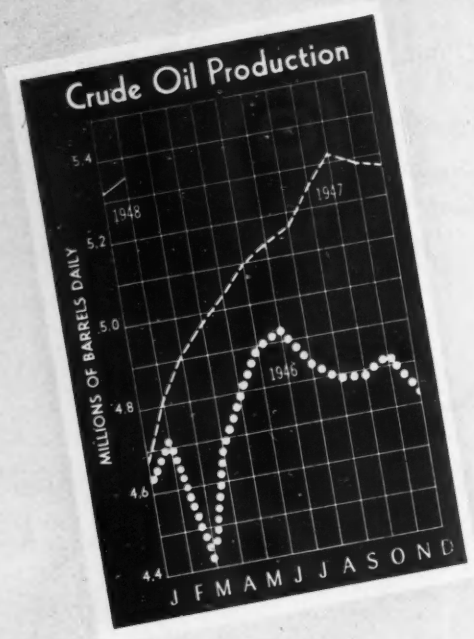
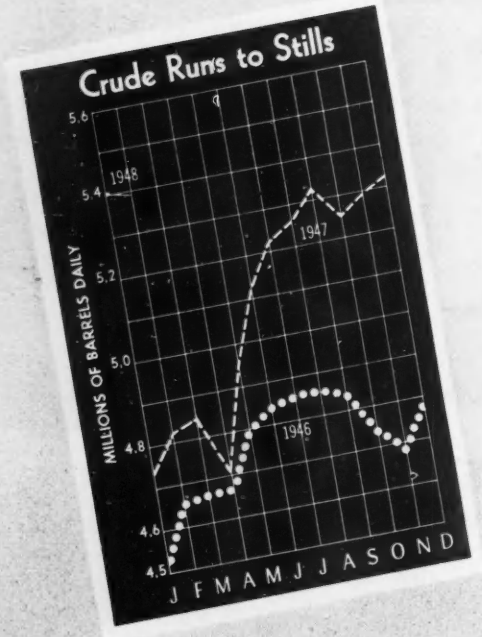
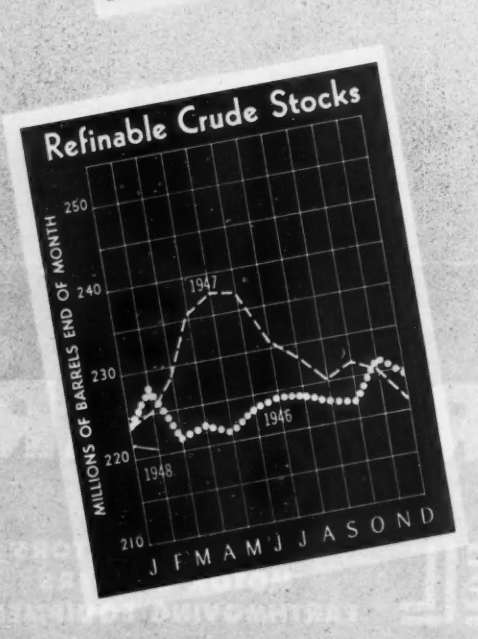






Petroleum

Crude Production Soars

By CECIL SMITH

DURING February the nation's oil fields were produced at a new all-time daily rate and its refineries were operated at about their practical limits as the all-out race between supply and demand continued. As in the preceding winter months the main issue confronting the industry was the furnishing of sufficient fuel oil to meet the nation's requirements, but this was by no means the only problem. In a matter of weeks the oil demand picture will begin its seasonal turnabout, when fuel oils will be replaced by gasoline as the principal product.

In order that this coming situation can be adequately met, refiners have had to place considerable emphasis on building gasoline stocks along with maximum output of fuel oils. This has resulted in gasoline stocks being pushed to a new record high, but with the probability of motor fuel consumption during this summer season also reaching new highs these stocks still can not be considered adequate.

Despite the month's increased daily crude output, supplies did not prove sufficiently to feed the refinery stills. Even importation of crude did not make up the difference and the result was that comparatively low crude stocks were further lowered. Further evidence of shortness of crude supplies are recent reports of premiums over posted prices being paid. These bonuses are the results of buyers bidding for the available material and they will continue until the supply adequately fills the needs of all. In the past these premium payments were forerunners of general crude

Crude Oil and Refined Products Trends

(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month
1945:									
January	4,756	4,680	221,737	2,094	91,666	663	31,695	1,350	44,347
February	4,767	4,817	220,221	2,194	97,457	724	27,210	1,326	39,760
March	4,804	4,719	223,988	2,124	97,447	675	26,729	1,273	35,451
April	4,807	4,774	224,229	2,127	90,804	681	29,148	1,289	34,418
May	4,887	4,913	223,151	2,179	88,530	708	29,511	1,341	34,333
June	4,859	4,989	218,218	2,166	86,128	730	32,440	1,351	35,606
July	4,897	5,001	216,638	2,281	85,582	713	36,276	1,351	38,341
August	4,870	4,928	215,135	2,269	84,003	701	41,245	1,329	42,227
September	4,423	4,275	220,319	1,933	74,574	640	45,059	1,139	42,822
October	4,284	4,244	221,246	1,888	76,805	613	45,479	1,176	42,068
November	4,517	4,624	218,916	2,156	86,540	665	44,562	1,265	41,322
December	4,472	4,574	218,763	2,056	97,676	683	35,778	1,245	37,158
1946:									
January	4,625	4,520	223,442	1,914	102,394	787	28,990	1,224	34,573
February	4,719	4,651	227,220	1,884	104,836	823	25,511	1,243	34,008
March	4,414	4,661	221,400	1,900	104,161	816	29,922	1,213	32,995
April	4,673	4,663	222,480	1,943	98,744	773	32,064	1,247	35,206
May	4,785	4,794	221,592	2,016	93,960	753	33,385	1,220	38,932
June	4,896	4,836	223,140	2,055	91,971	777	38,824	1,219	41,492
July	4,922	4,856	224,351	2,102	87,778	793	46,439	1,163	45,446
August	4,836	4,856	224,157	2,189	86,745	765	54,068	1,159	48,186
September	4,790	4,839	222,417	2,143	87,021	796	62,019	1,150	54,012
October	4,785	4,736	222,177	2,117	85,952	788	76,780	1,090	55,580
November	4,823	4,684	226,453	2,162	88,587	791	68,145	1,101	52,735
December	4,725	4,780	224,473	2,168	92,742	805	59,912	1,159	47,094
1947:									
January	4,671	4,739	223,848	2,078	99,623	778	48,197	1,174	41,550
February	4,810	4,820	225,121	2,089	103,672	777	36,901	1,228	48,480
March	4,908	4,843	228,981	2,076	105,679	825	31,423	1,222	37,403
April	4,974	4,707	235,710	2,037	101,724	764	30,268	1,148	36,455
May	5,033	4,947	237,768	2,128	95,209	805	34,279	1,204	39,992
June	5,099	5,120	237,278	2,258	89,774	807	39,676	1,233	43,515
July	5,137	5,221	230,974	2,302	86,003	847	46,444	1,244	47,600
August	5,173	5,260	228,523	2,383	85,849	869	54,707	1,245	51,334
September	5,251	5,236	225,258	2,375	84,360	911	59,764	1,237	52,578
October	5,320	5,253	226,666	2,371	82,584	938	63,252	1,260	52,502
November	5,291	5,291	225,462	2,332	87,551	942	61,334	1,245	52,455
December	5,337	5,350	224,929	2,347	92,303	992	51,081	1,282	47,091
1948:									
January	5,321	5,403	221,663	2,342	102,973	1,082	40,580	1,290	44,419
February	5,354	5,399	220,507	2,233	111,040	1,131	33,836	1,282	42,853
February, 1948 Changes:									
In Month	+33	—4	—1,156	—109	+8,067	+49	—6,744	—8	—1,566
In One Year	+544	+579	—4,614	+144	+7,368	+354	—3,065	+54	—5,627
In Two Years	+635	+748	+6,713	+349	+6,204	+308	+8,325	+39	+8,845

Trends

to New High in February

Staff Writer

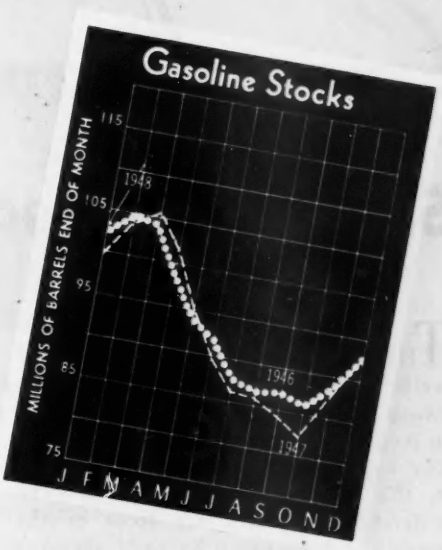
price increases and perhaps the same outcome can be expected from this situation. Bonus payers are mostly brokers and small refiners who do not have their own producing properties. These alone can not immediately swing prices upward, but when they began to threaten the sources of the major buyers by causing connections to be lost, this competition crystalizes into general increased postings. At present, these payments range from 10 to 25 cents a barrel and are most prevalent in East Texas and on the Texas Gulf Coast. Since the last overall increase in December, 1947, crude production has continued to increase. Perhaps the one that now seems probable will have some of the same stimulating effects.

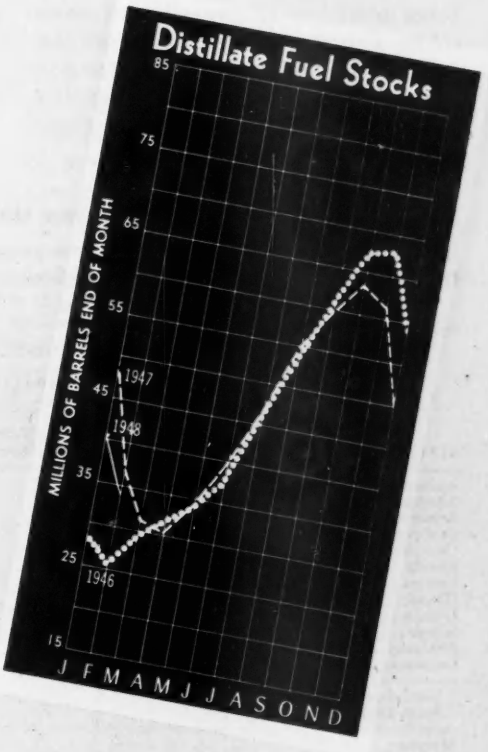
Daily crude production averaged 5,354,000 barrels during February to set a new all-time record. That was an increase of 33,000 barrels a day over January's output and 544,000 barrels daily over February, 1947.

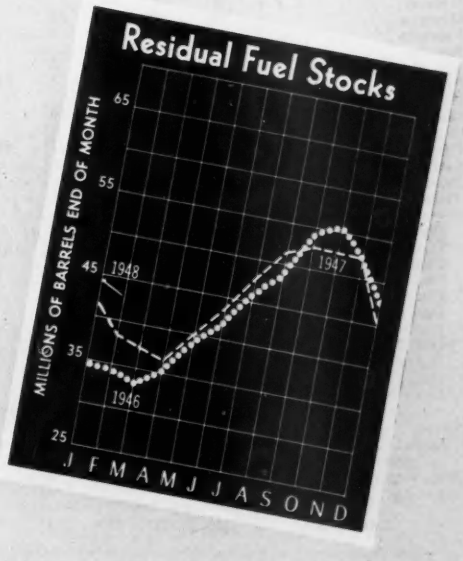
Crude oil was refined at the rate of 5,399,000 barrels a day during the month. That was not a new record, but it was only 4000 barrels a day under January's all-time peak. These daily runs to stills were 579,000 barrels more than those of February last year.

Stocks of refinable crude totaled 220,507,000 barrels at the end of February after having been reduced by 1,156,000 barrels during the period. A year before these stocks amounted to 225,121,000 barrels and totaled 265 million barrels in 1941.

Inventories of finished and unfinished gasoline amounted to 111,040,000 barrels at the close of February, showing a gain for the month of 8,067,000 barrels. This is the highest stocks have ever risen, with the previous high having been 109,281,000 barrels in March, 1942. Last year's highest was 107,576,000 barrels. But even with this gasoline stockpile, spot shortages appear inevitable this summer.







State Crude Oil Production

(THOUSANDS OF BARRELS)

STATE OR DISTRICT	DAILY AVERAGE PRODUCTION				TOTAL FIRST TWO MONTHS		
	February, 1948	January, 1948	February, 1947	% Diff. Feb. '47-'48	1948	1947	% Diff. '47-'48
Alabama	1.3	1.3	0.9	+ 44.4	79	57	+ 38.6
Arkansas	81.1	81.0	80.2	+ 1.1	4,862	4,698	+ 3.5
California	930.3	931.0	900.8	+ 3.3	55,841	52,632	+ 6.1
Colorado	45.7	45.5	36.5	+ 25.2	2,737	2,185	+ 25.3
Florida	0.8	0.8	0.1	+700.0	46	12	+283.3
Illinois	174.7	171.0	189.4	— 7.8	10,367	11,287	— 8.2
Indiana	18.2	17.7	17.0	+ 7.1	1,078	1,014	+ 6.3
Kansas	277.4	289.2	271.8	+ 2.1	17,012	15,956	+ 6.6
Kentucky	26.0	26.6	24.2	+ 7.4	1,579	1,479	+ 6.8
Louisiana	461.9	460.7	419.6	+ 10.1	27,677	24,594	+ 12.5
North Louisiana	108.7	107.2	98.0	+ 10.9	6,474	5,640	+ 14.8
South Louisiana	353.2	353.5	321.6	+ 9.8	21,203	18,954	+ 11.9
Michigan	44.9	46.9	43.0	+ 4.4	2,755	2,526	+ 9.1
Mississippi	115.6	114.8	84.0	+ 37.6	6,914	5,072	+ 36.3
Missouri	0.2	0.2	0.2	.....	9	8	+ 12.5
Montana	24.2	24.5	22.9	+ 5.7	1,462	1,331	+ 9.8
Nebraska	0.5	0.5	0.6	— 16.7	30	41	— 26.8
New Mexico	125.4	123.4	106.0	+ 18.3	7,462	6,125	+ 21.8
New York	13.9	13.9	12.5	+ 11.2	835	768	+ 8.7
Ohio	9.0	8.3	7.2	+ 25.0	520	437	+ 19.0
Oklahoma	409.3	406.5	371.3	+ 10.2	24,470	21,668	+ 12.9
Pennsylvania	33.1	32.7	32.9	+ 0.6	1,974	2,030	— 2.8
Tennessee	.....	.....	.....	.....	2	1	+100.0
Texas	2,417.8	2,383.7	2,070.7	+ 16.8	144,009	118,683	+ 21.3
Dist. 1—South Central	25.7	25.6	19.9	+ 29.1	1,537	1,149	+ 33.8
Dist. 2—Middle Gulf	172.1	168.1	145.5	+ 18.3	10,202	8,205	+ 24.3
Dist. 3—Upper Gulf	498.4	496.3	449.6	+ 10.9	29,839	25,390	+ 17.5
Dist. 4—Lower Gulf-S.W.	254.6	255.6	222.7	+ 14.3	15,310	12,641	+ 21.1
Dist. 5—East Central	44.4	44.0	36.4	+ 22.0	2,652	2,065	+ 28.4
Dist. 6—Northeast	437.5	415.3	433.1	+ 1.0	25,562	24,574	+ 4.0
Dist. 7-B—N. Central	45.1	42.9	36.0	+ 25.3	2,638	2,064	+ 27.8
Dist. 7-C—W. Central	44.4	42.8	32.5	+ 36.6	2,612	1,765	+ 48.0
Dist. 8—West	663.8	658.7	467.3	+ 42.1	39,670	27,572	+ 43.9
Dist. 9—North	145.4	142.4	126.1	+ 15.3	8,630	7,195	+ 19.9
Dist. 10—Panhandle	86.4	92.0	83.1	+ 4.0	5,357	4,868	+ 10.0
Virginia	0.1	.....	0.3	— 66.7	3	16	— 81.3
West Virginia	7.3	6.8	6.5	+ 12.3	424	410	+ 3.4
Wyoming	134.8	133.5	111.9	+ 20.5	8,048	6,463	+ 24.5
Total United States	5,353.5	5,320.5	4,810.5	+ 11.3	320,195	279,493	+ 14.6

Completions

Slowed by Weather

THE nation's drillers completed fewer wells in February than in January, which is normal due to the difference in length of the two months and generally more favorable weather conditions in the earlier period. While the time difference accounted for some of the margin, a comparison by daily averages showed that January was still the leader. Some areas had to contend with severe cold in February, while others were handicapped by high water. Many rigs that had completed their jobs during January were either prevented or delayed in moving to new sites by impassable roads or flooded locations. These conditions were not entirely confined to February and they undoubtedly will be reflected in March's drilling results.

A better picture of what the industry is doing in the way of providing new wells comes from the comparison of the present with the past year. This year started with the first month's completions topping those of a year before by over 30 percent, and while February failed to hold so large a lead, it did better last year's record by about 8 percent. At the end of two months the 1948 ledger showed an increase of 874 wells or 18.8 percent over the same period a year ago.

Of February's 2532 wells, 1468 were completed as crude or distillate producers, accounting for 57.8 percent of the total. A year ago these wells totaled 1265 and amounted to only 54.1 percent of the over-all, showing not only an increase in drilling, but also a slightly better success ratio. Gas wells totaled 213 or 8.6 percent, while a year ago they were up to 12.2 percent. The remaining were either dry or service wells and their percentages of the totals were the same in each of the two comparable months.

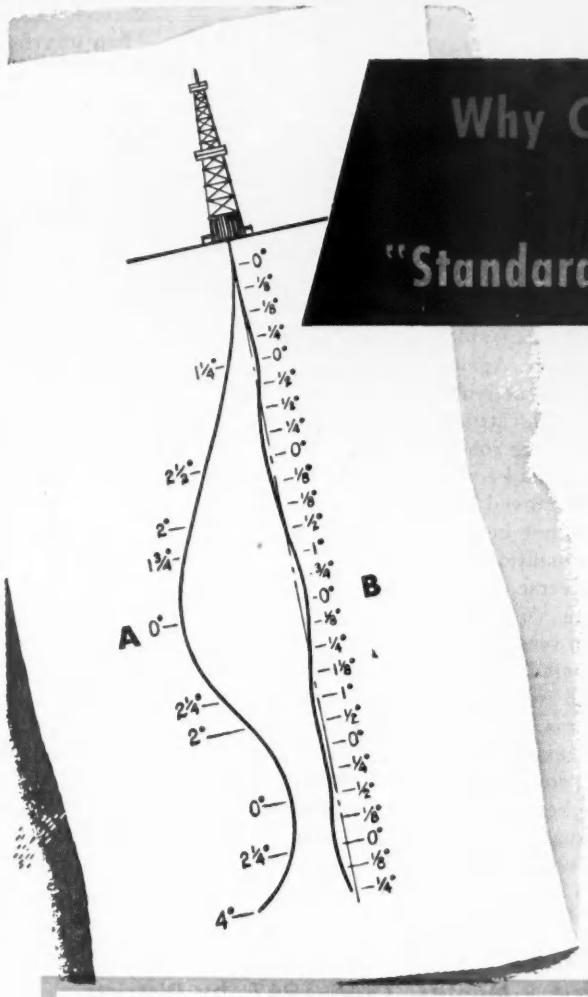
At the end of February there were 4542 active drilling rigs, compared with 4699 a month earlier. A year before there were 4402 drilling units in operation. The difference between the February and January figures is probably due to rigs having been stacked on account of weather and for overhaul and maintenance.

Well Completions in the United States During February, 1948, and Cumulative for Year

(Figures compiled by WORLD OIL Staff from private reports and other sources as follows: Illinois from Illinois Geological Survey; Indiana from Indiana Division of Geology; Missouri from Missouri Geological Survey; Tennessee from Tennessee Division of Geology; Bradford, Kane-Clarendon, and Allegany fields of Pennsylvania and New York from The Producers' Monthly)

STATE OR DISTRICT	MONTHLY COMPLETIONS, FEBRUARY, 1948 — NEW WELLS: Oil	Dist.	Gas	Dry	Water Input	Gas Input	Water Disposal	Total New	Total Drilled Deeper	TOTAL COMPLETIONS: Feb., 1948	Jan., 1948	Feb., 1947	Footage February, 1948	CUMULATIVE TOTAL January-February: Wells 1948	Wells 1947	Percent Diff.	Footage 1948	Rigs in Operation (Drilling, Rigging Up and Shut Down): Feb. 29, 1948	Jan. 31, 1948	Feb. 28, 1947
Alabama				1				1		1	1	3	2,727	2	3	— 33.3	11,735	2	1	3
Arizona																		1	1	2
Arkansas	13			8				21		21	31	13	81,726	52	30	+ 73.3	198,147	31	35	31
California	174	1	1	26				202		202	220	155	727,215	422	304	+ 38.8	1,487,096	281	293	309
Colorado	15			7				22		22	27	11	116,981	49	20	+145.0	257,219	62	59	46
Florida				2				2		2	3	4	9,240	5	7	— 28.6	38,222	5	4	6
Georgia																		2		1
Illinois	98			77				175	1	176	146	133	440,337	322	280	+ 15.0	824,564	193	203	229
Indiana	29		2	11				42		42	77	33	82,664	119	67	+ 77.6	220,650	96	113	75
Kansas	92		23	72			2	189		189	208	212	619,463	397	383	+ 3.7	1,321,388	288	321	327
Kentucky	13		23	8				44		44	65	54	90,770	109	110	— 0.9	223,587	69	70	100
Louisiana	65	10	3	33				111		111	145	93	583,348	256	203	+ 26.1	1,351,990	194	196	146
North Louisiana	47	6	3	16				72		72	78	49	215,984	150	104	+ 44.2	408,926	56	60	49
South Louisiana	18	4		17				39		39	67	44	367,364	106	99	+ 7.1	943,064	138	136	97
Maryland											1			1			5,259			
Michigan	20		2	33				55		55	57	30	136,228	112	70	+ 60.0	265,245	90	96	129
Mississippi	18	2		10				30		30	36	21	271,702	66	47	+ 40.4	581,838	42	52	70
Missouri	6							6		6		4	2,674	6	14	— 57.1	2,674	4	5	
Montana	10		1	10				21		21	28	3	52,455	49	12	+308.3	133,515	46	62	37
Nebraska				1				1		1			4,965	1			4,965		1	6
Nevada																			1	
New Mexico	37		5	5				47	3	50	56	43	224,076	106	85	+ 24.7	436,380	124	108	110
New York	88		2	3	54			147		147	145	129	213,810	292	237	+ 23.2	417,036	159	184	101
North Carolina																				1
Ohio	21		24	25				70	1	71	91	79	204,325	162	200	— 19.0	478,507	212	211	232
Oklahoma	155		23	75				253	7	260	355	303	918,110	615	574	+ 7.1	2,127,178	553	541	484
Pennsylvania	85		44	21	67	24		241	3	244	266	257	434,930	510	532	— 4.1	892,565	347	368	371
South Dakota																		1	1	
Tennessee											3	1		3	2	+ 50.0	6,177	19	19	10
Texas	489	9	27	262				787	22	809	871	711	3,481,826	1,680	1,295	+ 29.7	7,217,561	1,280	1,290	1,134
Dist. 1—S. Central	21			18				39	1	40	40	32	134,011	80	54	+ 48.1	254,240	61	50	28
Dist. 2—Middle Gulf	30	4	1	13				48	3	51	71	53	285,877	122	92	+ 32.6	692,028	64	55	43
Dist. 3—Upper Gulf	29	3	2	29				63	2	65	77	55	430,496	142	115	+ 23.5	948,538	91	113	87
Dist. 4—L. Gulf-S.W.	40	2	3	45				90	2	92	104	98	481,555	196	161	+ 21.7	991,961	125	116	108
Dist. 5—E. Central	7			3				10		10	16	7	70,407	26	16	+ 62.5	134,848	34	33	25
Dist. 6—Northeast	14		2	7				23		23	39	32	130,509	62	70	— 11.4	340,785	49	50	73
Dist. 7-B—N. Central	39		8	52				99	3	102	93	73	332,828	195	127	+ 53.5	593,205	116	124	124
Dist. 7-C—W. Central	20			11				31		31	28	23	103,341	59	30	+ 96.7	218,422	67	62	71
Dist. 8—West	184			23				207	9	216	199	139	990,631	415	266	+ 56.0	1,919,353	451	443	324
Dist. 9—North	77		2	60				139	2	141	159	165	407,225	300	294	+ 2.0	874,947	93	115	140
Dist. 10—Panhandle	28		9	1				38		38	45	34	114,946	83	70	+ 18.6	249,234	129	129	111
Utah				2				2		2	2		5,240	4			6,777	12	14	6
Virginia			1					1		1			2,301	1			2,301			
Washington																		1	1	1
West Virginia	7		32	7				46	2	48	77	74	118,880	125	136	— 8.1	298,304	328	365	380
Wyoming	11			5				16	2	18	36	15	72,876	54	35	+ 54.3	218,896	99	84	55
Total U. S.	1,446	22	213	704	121	24	2	2,532	41	2,573	2,947	2,381	8,898,869	5,520	4,646	+ 18.8	19,029,776	4,542	4,699	4,402

Why Controlled Vertical Drilling with a TOTCO is "Standard Practice" all over the world



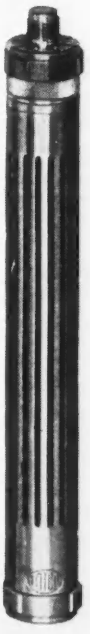
A straight hole is quicker, easier and cheaper to drill than a crooked one. It's a trouble-free producer, too.

The illustration at left shows why this is so. Look at hole "A." Looks like the first inclination reading was taken too late and subsequent readings were too few and too far apart to guide the driller in drilling a vertical hole. That dogleg is a natural for stuck casing or keyseating, isn't it? Efforts to correct it have only made matters worse. Chances are that there'll be a nasty fishing job in this hole before long.

Now look at hole "B." On this well the driller took frequent inclination readings, and used this information in determining the correct rotation speed and weight on the bit for drilling ahead. Not much room for trouble here, is there? And that's where Controlled Vertical Drilling really shows a substantial saving. Because trouble costs money. Stuck casing, keyseating, twist-offs, fishing jobs, backing up and re-drilling—any one or any combination of these results of crooked hole can mean the difference between success and failure from a profit standpoint.

When you think it over, can you *afford* to drill anything but a vertical hole?

The TOTCO RECORDER



Here's the instrument that can tell you exactly what's happening in the hole—the TOTCO Recorder. With TOTCO you can get an accurate, dependable reading of inclination *at any time*. Any member of the drilling crew can handle the TOTCO, and it takes only a few minutes to run it in the hole. And the driller can immediately read and correctly interpret the record the TOTCO produces.

Yes, the TOTCO Recorder is the kernel of Controlled Vertical Drilling. TOTCO Records, accurate right down to one-eighth of a degree, are the only safe guide for determining the correct drilling weight and rotation speed. You can take *frequent* readings, too, with any one of the 5 easy ways of running the Recorder.

Totco Equipment is leased or rented in the U.S.A.; sold for export only.

TOTCO supplies Go-Devils and accessory equipment for running the TOTCO Recorder on sand line or measuring line and in conjunction with wire line core barrel retrieving equipment; for dropping freely in the drill pipe; and for running in the bailer in cable-tool-drilled wells.

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Exploration

In Seasonal Slump

Summary of Results of Exploratory Drilling

ITEM	Feb., 1948	Jan., 1948	TWO MONTHS JAN.-FEB. 1948	1947	Percent Diff.
Oil Discoveries	60	66	126	99	+ 27.3
New Fields	35	42	77	60	+ 28.3
New Pays	25	24	49	39	+ 25.6
Distillate Discoveries	4	10	14	17	— 17.6
New Fields	3	3	6	6	.....
New Pays	1	7	8	11	— 27.3
Gas Discoveries	9	9	18	12	+ 50.0
New Fields	8	5	13	8	+ 62.5
New Pays	1	4	5	4	+ 25.0
Total Discoveries	73	85	158	128	+ 23.4
Extensions to Fields	12	12	24	19	+ 26.3
Oil Fields	9	10	19	15	+ 26.7
Distillate Fields	3	1	4	3	+ 33.3
Gas Fields	.....	1	1	1	.....
Total Prod. Tests	85	97	182	147	+ 23.8
Dry Holes	329	414	743	624	+ 19.1
Wildcats	324	408	732	605	+ 21.0
New Pays	1	1	2	11	— 81.8
Outposts	4	5	9	8	+ 12.5
Total Expl'tory Tests	414	511	925	771	+ 20.0
Percent Productive	20.5	19.0	19.7	19.1	.....
Percent Dry	79.5	81.0	80.3	80.9	.....

FEBRUARY'S exploratory completions dropped sharply from the previous month's as a result of the shortness of the period and the extreme weather experienced in some regions. The entire drilling program was slowed during the month due to cold weather and rains, but the exploratory phase suffered the greater setbacks.

The over-all drilling campaign, which includes exploratory and general development drilling, resulted in 12.7 percent fewer wells completed in February than in January, but exploratory wells declined 19 percent. Some of this was due to natural reaction to the cold weather by operators who chose field development jobs instead of wildcats in remote areas. Other regions, while not plagued with ice and snow, had to contend with heavy rains that left roads impassable and locations covered with water. Again in these regions the development activity was less handicapped than wildcatting because of the availability of better roadways. In many cases after a rig had completed its hole it could not be moved because of the roads or could not be relocated because of flooded conditions at the stated location. These adverse conditions will also have some curtailing effect on March's completion record.

Exploratory wells completed during February numbered 414, of which 85 were rated as successful for a score of 20.5 percent. In January, 511 exploratory tests completed yielded 97 producers or 19 percent. A slightly higher success ratio was attained in February of last year, but the totals were considerably smaller, having been 76 successful wells out of 365 ventures.

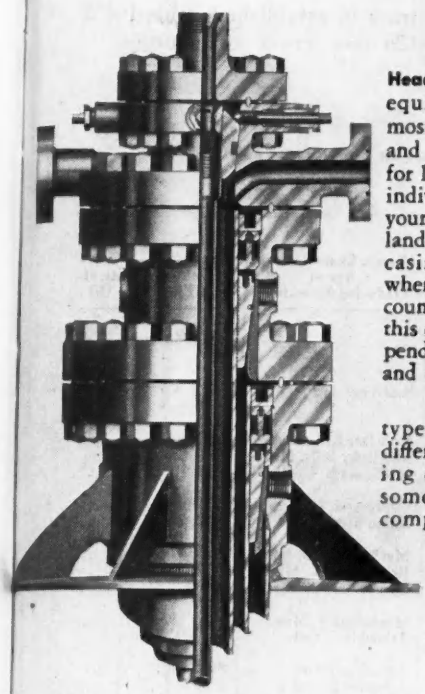
Strict wildcats or wells drilled in unproved territory continued to make up about 90 percent of the exploratory totals. In February these wildcats amounted to 89.4 percent of all exploratory tests and in January they were 89.6 percent. A year ago in February these wells

Results of Exploratory Drilling in February and First 2 Months, 1948-1947, by Districts

State or District	MONTH OF FEBRUARY, 1948													FIRST TWO MONTHS, 1948																
	Productive Tests										Unproductive Tests				Productive Tests									Unproductive Tests				Total Exploratory Tests	
	New Fields			New Pays			Extensions			Total Productive	Wildcats	New Pays	Outposts	Total Exploratory Tests	New Fields			New Pays			Extensions			Total Productive		Wildcats	New Pays	Outposts	Total Dry			
	Oil	Gas	Dis.	Oil	Gas	Dis.	Oil	Gas	Dis.						Oil	Gas	Dis.	Oil	Gas	Dis.	Oil	Gas	Dis.	1948	1947				2 Mo. 1948	2 Mo. 1947	2 Mo. 1948	2 Mo. 1947
Alabama											1			1												2			2	2	2	2
Arkansas											5			5	1									1		14			14	6	15	6
California	1								1	2	20			22	2			1					1	4	1	43			43	36	47	37
Colorado											5			5											1	12			12	4	12	5
Florida											2			2												3			3	7	3	7
Illinois	2			2			3			7	41			48	3			5			5			13	21	71			71	52	84	73
Indiana											4			4	1	1		1						3		15			15	10	18	10
Kansas	4									4	26			30	10									10	11	62			62	56	72	67
Kentucky																1					1			2		3			3	10	5	10
Louisiana	1		1	2					2	6	11		1	18	1		1	7		3			2	14	19	24		1	25	35	39	54
North Louisiana									1	1	7			8									1	1	2	12			12	21	13	23
South Louisiana	1		1	2					1	5	4		1	10	1		1	7		3			1	13	17	12		1	13	14	26	31
Maryland																										1			1		1	
Michigan	2									2	23			25	3	1								4	1	42			42	32	46	33
Mississippi											6			6											3	15			15	12	15	15
Missouri																														7		7
Montana											2			2	1									1		8			8	3	9	3
New Mexico	1									1	2			3	3			2						5	1	9			9	10	14	11
Ohio											3			3	1						1			2		8			8	7	10	7
Oklahoma	3	2		6						11	29			40	5	3	2	7			1			18	23	78			78	105	96	128
Pennsylvania											2			2												2			2		2	
Tennessee																										2			2	2	2	2
Texas	20	5	2	14	1	1	5			48	137	1	3	189	44	6	3	24	5	5	11		1	99	63	309	2	8	319	222	418	285
Dist. 1 S. Central				1						1	17			18				1						1	2	28			28	22	29	24
Dist. 2 Middle Gulf	3			2		1				6	9			15	6			3	1	3			1	14	7	29	1	2	32	19	46	26
Dist. 3 Upper Gulf	1		1	4						6	20			26	1		1	8	2		2			14	11	41		1	42	21	56	32
Dist. 4 L. Gulf-S.W.		1	1	3	1		1			7	26		1	34	2	2	2	4	2	2	1			15	15	52		2	54	34	69	49
Dist. 5 E. Central							1			1	2			3				2			1			3		13			13	13	16	13
Dist. 6 Northeast				3			2			5	5			10				3			2			5		15			15	7	20	7
Dist. 7-B N. Central	5	3								8	23			31	12	3								15	10	52			52	43	67	53
Dist. 7-C W. Cent.	2									2	9			11	5									5	1	15			15	4	20	5
Dist. 8 West	5									5	11	1	1	18	8			1			3			12	7	22	1	2	25	22	37	29
Dist. 9 North	4	1		1			1			7	15		1	23	10	1		2			2			15	9	42		1	43	37	58	46
Dist. 10 Panhandle																									1						1
Utah											2			2												4			4		4	
Virginia		1								1				1		1								1							1	
Wyoming	1			1			1			3	3			6	2			2			1			5	3	5			5	8	10	11
Total U. S.	35	8	3	25	1	1	9		3	85	324	1	4	414	77	13	6	49	5	8	19	1	4	182	147	732	2	9	743	626	925	773

For maximum safety IN CASING, TUBING and PRODUCTION OPERATIONS . . .

SHAFFER SPOOL TYPE LANDING HEADS



Shaffer Combination Landing Base Head, with Spool Type Landing Head and Shaffer Type 46 Tubing Head.

Shaffer Spool Type Landing Heads—*pioneer* of this type of equipment—still provide the most advanced, most adaptable and safest equipment available for landing and packing-off each individual string of casing in your wells. They can be used for landing the longest and heaviest casing strings, and on wells where highest pressures are encountered—your assurance that this equipment is completely dependable for modern drilling and completion requirements.

They are available in many types, and in a choice of *five* different packing units for packing off around the casing . . . some with threaded rings for compressing the packing . . . some with no threads whatever in the internal bore . . . and one with an all-metal packing unit ideal for handling certain types of crudes.

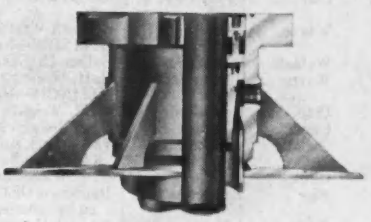
Available in all A.P.I. pressure ratings (Series 400, 600, 900, 1500 and 2500), all Shaffer Heads offer the following vital advantages . . .

- ★ Each individual string is landed with safety at any point desired without any necessity of "letting go," measuring or rethreading.
- ★ Each string is supported on its own flange with an upper flange provided for the support of the next string.
- ★ Each string is suspended on its own set of slips, with no accumulation of weight placed on those slips by subsequent strings of casing and tubing—nor is it affected by any load due to well pressures.
- ★ Each string is packed off securely against high pressure, with provision for gas outlet, mud line or overflow as required, and is packed off independent of any other head in the assembly.
- ★ Each Head is an independent self-contained unit and its packing-off arrangement does not depend upon other heads or flanges to effect a positive seal.

SHAFFER COMBINATION LANDING BASE HEADS

Shown below is a typical Shaffer Combination Landing Base Head—the type of landing head widely used on modern well completions where space is at a premium. These heads—available in 5 different types—provide both a Base and Head in *one* compact unit having a total vertical height equal to *or less than* the height of a conventional head *alone*.

The complete line includes types with standard packing units, with packing units in which no internal threads are used, and a type with all-metal packing unit.



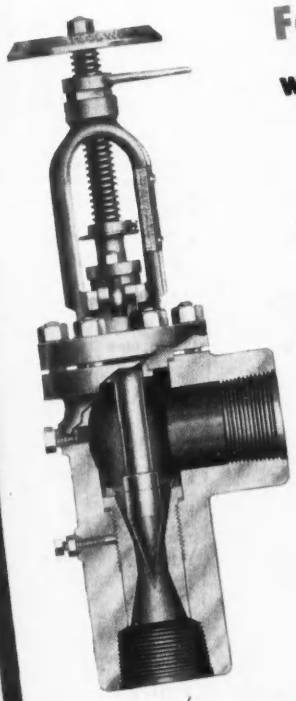
This Shaffer Model A Combination Landing Base Head—one of 5 types available—is typical of the unusual compactness and simplicity of these Base Head units.

ALL TYPES OF TUBING HEADS

A complete line of Shaffer Tubing Heads is also available to meet every completion requirement—plus multiple zone hook-ups and other special production equipment to meet varied production requirements.

For controlling FLUID FLOW with maximum safety, minimum turbulence—

SHAFFER ADJUSTABLE FLOW BEANS

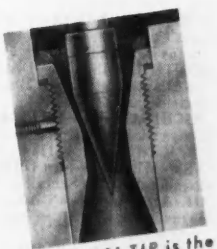


Shaffer is the organization that *pioneered* adjustable flow beans—and Shaffer design embodies *exclusive* features that insure longer life, higher flow efficiency and less maintenance.

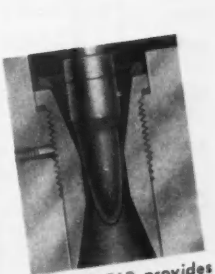
One very important feature is the *double tapered* orifice used in Shaffer Flow Beans. Because the discharge side of the orifice is tapered the same as the entrance side, the fluid flow on the discharge side is expanded *gradually* to the full diameter of the discharge pipe, greatly minimizing turbulence and emulsification.

Because emulsification is reduced, treating costs are lower and greater all around flow efficiency is obtained. Another advantage—Shaffer Flow Beans may be connected so that the flow is either *toward* or *against* the tip, permitting wider versatility for meeting installation requirements.

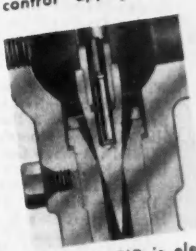
And note at right the various types of tips available with Shaffer Adjustable Flow Beans to meet virtually *any* flow requirement. Widely used for drilling, production and refinery applications, Shaffer Adjustable Flow Beans are available in many types and sizes . . . with flanged or screwed connections . . . bolted or screwed yokes . . . in sizes from 1" to 6" . . . and with pressure ratings to 10,000 lbs. per square inch.



CONICAL TIP is the standard type used for the majority of control applications.



MICRO TIP provides equal increase in opening area for each turn of hand wheel.



THERMO TIP is electrically heated to prevent ice or wax formation in the orifice.

HARD METAL TIP is available in all tip designs to resist abrasive-laden fluids.

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amounted to 86.3 percent of the total. The remainder were attempts to extend the boundaries of known fields or to establish new pay horizons within proved areas.

In the first two months of this year exploratory completions totaled 925 against 771 in the comparable months of 1947. This amounted to an increase of 20 percent over last year. So far this year's exploratory drilling has netted 182 successful tries, 19.7 percent of the total, and a year ago 147 producers amounted to 19.1 percent.

In these months the industry's efforts have uncovered 77 new oil fields and 49 new oil strata in established fields for a total of 126 new crude oil sources.

New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in February, 1948

Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		CALIFORNIA—New Oil Field						
Santa Barbara	.....	Tide Water Assoc Oil Co's Luton 135, 29-8n-31w, Zaca Area, 2900 n 8400 w swc Rancho La Zaca.	2-12-48	5301	.....	.....	P 144; 56 wtr	26
		CALIFORNIA—Distillate Field Extension						
Los Angeles	Lawndale.....	Seaboard Oil Co's Pauley-Seaboard 81-20, 20-3s-14w, ¾ mi se extension.....	2- 6- 48	7996	7950- 7996	Schist cgl; Jur	F 238; 4.5 mln; 1/16"	60.4
		ILLINOIS—New Oil Fields						
Clay.....	Clay City, N..	Calvert & Willis—Ashland's Bemis 1, sw se ne 8-3n-8e, 2 mi n Clay City Cons fld.	2- 3-48	3094	3005- 3033 3036- 3042	Rosiclare li; L. Miss McClosky li; L. Miss	P&F 365	....
Wayne.....	Mayberry, N..	George & Wrather's M. Monroe 1, ne nw ne 27-2s-6e, 1¾ mi sw Covington, S pl.	2-10-48	3440	3351- 3354	McClosky li; L. Miss	P 75; 10 wtr	....
		ILLINOIS—New Oil Pays						
Wabash....	Mt. Carmel,W.	Gilliam Drlg Co's G. Seits 1, nw nw se 23-1s-13w, also 1 mi ne extension....	2- 3-48	2288	2282- 2288	Cypress sd; U. Miss	P 219	....
Wayne.....	Aden Consol..	H. H. Weinert's Morlan "A"-2, (OWDD), ne se nw 33-2s-7e, 30 mi w Salem pl.	2- 3-48	3756	3737- 3756	Salem li; L. Miss	P 22; 7 wtr	....
		ILLINOIS—Oil Field Extensions						
Clay.....	Stanford, S...	W. H. Wright's G. McLaughlin 1, nw nw nw, 17-2n-7e, ¾ mi w extension...	2-24-48	3116	3107- 3116	McClosky li; L. Miss	P 25; 37 wtr	....
Clay.....	Toliver, E....	Nash Redwine's G. McGee 1, se se ne, 24-5n-6e, 1 mi n extension.....	2-10-48	2827	2817- 2821	Rosiclare li; L. Miss	P 42; 60 wtr	....
Gallatin....	Inman, E.....	Vandenbark Bros' Big Barn 1, sw ne ne, 10-8s-10e, ¾ mi extension.....	2-10-48	2420	2404- 2420	Cypress sd; U. Miss	P 108	....
		KANSAS—New Oil Fields						
Cowley....	.....	K. T. Wiedemann's Haydensmith 1, sw nw nw 28-30s-7e, 3 mi n Clover pl....	2-17-48	2854	2840- 2854	Mississippi li; Miss	P 7	....
Rice.....	Haferman, E..	Henderson Oil Co's Keller 1, sw nw ne 5-19s-9w, ½ mi e Haferman fld, separated by failures.	2-24-48	3246	3242- 3246	Arbuckle li; Ord	Sw 240	....
Rooks.....	Northampton..	Nadel & Gussman & Hay's Marcotte 1, nw nw sw 26-9s-20w, 3 mi ne Palco fld.	2-25-48	3814	3812- 3814	Arbuckle li; Ord	Sw 2200	....
Stafford....	.....	Armer & Lindas' Bommeke 1, nw nw se 21-21s-12w, 1 mi e Mueller pl.....	2-10-48	3575	3565- 3575	Arbuckle li; Ord	P 50	....
		NORTH LOUISIANA—Distillate Field Extension						
Bienville...	Bear Creek...	C. H. Murphy Jr's Pipes 1, c se sw 19-17n-5w, 2 mi ne extension.....	2- 4-48	8324	7650- 7680	Travis Peak sd; L. Cre	F 112; 32 mln; open	63
		SOUTH LOUISIANA—New Oil Field						
Beauregard	Hurricane Creek	Magnolia Pet Co's Four C. McPherson 1, 660 n&w of sec nw¼ se¼ 26-5s-8w, 5 mi e Longville twst.	1-27-48	9009	8415- 8420	Cockfield sd; Eoc	F 120; 4/64"	43.8
		SOUTH LOUISIANA—New Oil Pays						
Iberia.....	Weeks Island.	Humble O&R Co's R. H. Goodrich et al 2, fr USCGS Sta "Weeks 2" n 73 deg 19 min w 5700 to locn in 14s-6e.	2-10-48	8139	7968- 7976	.....	F 138; 138 wtr; 4/64"	30.7
St. Martin..	St. Martinville	Continental Oil Co's Barras-Isidore Unit 2, fr w cor 66-11s-6e go e alg nl 1440 th s at ra 425 to locn.	2- 3-48	5109	4280- 4294	Miocene	F 90; 1/8"	25.8
		SOUTH LOUISIANA—New Distillate Field						
Pointe Coupee	.....	Texas Co's Lottie Ld & Dev Co 1, 660 n 702 w fr sec nw¼ Sect 25-6s-8e, 6½ mi ne Krotz fld.	2- 8-48	10509	8848- 8862	.....	F 62; 8.3 mln; ½"	53.2
		SOUTH LOUISIANA—Distillate Field Extension						
Acadia.....	Egan.....	The Atlantic Ref Co's H. Dommert 1, 2000 e 1986 n of swc 29-9s-2w, ¾ mi w extension.	2-19-48	10796	10664-10684	Hayes sd; Olig	F 35; 1.6 mln; 4/32"	60
		MICHIGAN—New Oil Fields						
Berrien....	.....	Sewage Sanitation Co's John Foster Estate 1, se nw nw, 2-7s-17w, Niles twp.	2-29-48	655	645- 655	Traverse li; Devo	P 125	....
Montcalm..	.....	J. E. Hood's Hopkins 1, sw nw nw 36-9n-6w, Bushnell Twp.....	2- 1-48	2670	2630- 2636	Traverse li; Devo	P 7	....
		NEW MEXICO—New Oil Field						
Lea.....	.....	Magnolia Pet Co's Santa Fe 1-A, 660 fr s&el 30-9s-36e, 4½ mi n Ranger Lake	2-10-48	4840	4832- 4840	San Andres li; Perm	P 16; 11 wtr	28
		OKLAHOMA—New Oil Fields						
Caddo.....	Cement, N...	Magnolia Pet Co's Miller 1-A, se nw ne 14-6n-9w, n of Cement fld in W. Laverty area.	2-26-48	13046	10630-10655	Pennsylvania sd; Penn	F 195; ½"	44
Garvin.....	.....	Cities Service et al's Rogers "B" 2, ne nw se 25-4n-4w, 4 mi s prod.....	2-19-48	8480	8020- 8044	Pennsylvania sd; Penn	P 17	42
Pontotoc...	.....	W. A. Delaney Jr's Huddleston 1, sw ne se 25-4n-6e.....	2-19-48	1740	1134- 1148	Senora sd; Penn	P 14	30
		OKLAHOMA—New Oil Pays						
Garvin.....	Antioch, N...	Magnolia Pet Co's Foreman Bull 1, nw nw ne 16-3n-2w.....	2-17-48	6435	6350- 6370	2nd Bromide sd; Ord	F 285; 4/64"	43.4
Garvin.....	Antioch, NE.	Sinclair-Prairie's R. C. Kennedy 1, nw ne nw 14-3n-2w.....	2-12-48	5828	5470- 5512	Viola li; Ord	F 37; 16 wtr	38
Garvin.....	Antioch, SW..	Sinclair-Prairie's Tulsa Univ. "B" 1, nw se sw 33-3n-2w.....	2-29-48	6807	6675- 6805	Hunton li; Devo	F 486	40.8
Garvin.....	Maysville, SW	Phillips Pet. Co's Eskridge 1, (OWWO), ne sw sw 18-4n-2w.....	2-29-48	7376	7068- 7116	Viola li; Ord	F 195; 4/64"	42
Okfuskee...	Castle, E.....	Texas Company's Tanner 3, sw ne ne 28-12n-9e.....	2-19-48	3296	3283- 3296	Wapanucka-Cromwell sd; Penn	F 105; 1 mln; 1/16"	39
Okfuskee...	Morse, W....	Wilcox Oil Co's Woodward 2, ne nw ne 13-12n-9e.....	2-29-48	3915	3906- 3913	Wilcox sd; Ord	P 52	45
		OKLAHOMA—New Gas Fields						
Oklahoma..	.....	British-American & Harper & Turner's Kramer 1, c sw nw 13-12n-2w.....	2-12-48	6271	6210- 6245	Hunton li; Devo	12.2 mln	....
Seminole...	.....	Hall, Troupe & Moore's Reed 1, ne sw ne 7-6n-7e.....	2-12-48	1526	1514- 1526	Calvin sd; Penn	5 mln	....
		VIRGINIA—New Gas Field						
Buchanan..	.....	United Producing Co's W. M. Ritter Lbr Co V-1, Garden district, 2000 s of 37 deg 15 min Richlands Quadrangle 12,000 e of 82 deg 00 min.	2-19-48	2301	.....	Maxton sd; Miss	17 mln; open	....
		TEXAS—District 1 (SOUTH CENTRAL—New Oil Pay						
Atascosa...	Jourdanton...	Humble O&R Co's A. J. Krause 2, 467 fr s&wl Lot 40, Natascosa Colony Farm Subd. James P. Gorman Sur.	2- 4-48	7658	7155-7164	.....	F 108; 4/64"	29.9
		TEXAS—District 2 (MIDDLE GULF COAST)—New Oil Fields						
DeWitt....	Holly.....	Holly Dev Co's Geo. Stanchos 1, 467 fr swl 2100 fr sel 2810 fr nwl of Jas. Kelly Sur. 4½ mi w-nw Meyersville.	2- 1-48	7615	7602- 7613	Wilcox sd; Eoc	F 165; 1/8"	35.2
Calhoun...	"Glasscock"..	C. G. Glasscock Jr & Pontiac Ref Co's McDonald & Frels 1, 660 fr nel 1650 fr nwl I&GN Sur, 6 mi s-se Sheriff fld.	2- 7-48	7304	7268- 7269	.....	F 112; 1/8"	41.2
Jackson....	Sandy Creek..	Rock Hill Oil Co et al's J. M. Halamicek 1, 2150 fr sl 8800 fr el of S. C. A. Rogers Sur, ½ mi nw Ganado, W., fld.	1-22-48	5610	4560- 4564	.....	F 108; 1/8"	25
		TEXAS—District 2 (MIDDLE GULF COAST)—New Oil Pays						
Goliad.....	Brandt.....	Sun Oil Co's Rob't. F. Goehring et al 1, 481 fr sl 467 fr e'ly line (at ra) of A. Mancha Sur.	2-22-48	7725	4707- 4720	Pettus sd; Eoc	F 102; 1/8"	46.8
Victoria....	Pridham Lake, W.	Rock Hill Oil Co et al's Johanna Vogt 1, 330 fr nw&swl of 53-ac lse in Rafael Manchola Gr on s edge of prod.	1-22-48	5025	4342- 4345	.....	F 91; 1/8"	....
		TEXAS—District 2 (MIDDLE GULF COAST)—New Distillate Pay						
Goliad.....	Hord's Creek.	Brown & Wheeler's J. R. Kuaffmann D-1-W, 660 fr se&swl of 300-ac lse "D" or 212 fr sel 2800 fr e'ly nel of P. Trevino Gr.	1- 8-48	8620	8395- 8398	Massive sd; Eoc	F 160; 40 40 mln; open	....
		TEXAS—District 3 (UPPER GULF COAST)—New Oil Field						
Liberty....	"Votaw".....	Miles Prod Co's Julia Hills 1, 2133.3 fr wl 241 fr nl of 188-ac lse or 2133.3 fr wl 577 fr nl of F. H. Votaw Sur. ½ mi se Cleveland, N. fld.	2-23-48	5787	5687- 5692	Yegua sd; Eoc	F 141; 4/64"	41.2

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formations abbreviated thus: Plio, Pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hr. rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity: size of choke given in inches.

■ TABLE CONTINUED ON PAGE 72

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New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in February, 1948—Continued

Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		TEXAS—District 3 (UPPER GULF COAST)—New Oil Pays						
Brazoria	Chenango, S.	Pan American Prod Co's Joe Heim Jr. 1, 660 fr n&el of 1122.8-ac Tr, Shubal Marsh Sur, ¾ mi ene of distillate disc.	2-10-48	10750	9200- 9207		F 132; 5/32"	31
Hardin	Beech Creek, E.	American Republics Corp's H&TC Fee 1, 3052.2 fr el 2210 fr sl of Sect 199. ¾ mi w & n of disc well.	2-22-48	7550	6653- 6657	Cockfield sd; Eoc	F 102; 39 wtr 1/4"	40.1
Matagorda	Whitson	Stanolind O&G Co's C. J. Anderson 3, (OWWO), 1400 fr el 660 fr sl of 538.85-ac lse, E. Hall Sur.	2-15-48	10800	8570- 8576		F 182; 1/8"	38
Newton	Sabine Tram.	Gulf Oil Corp's J. P. Bevil Sr et al 1-C, 560-ac in R. I. Richardson Sur. 660 fr n&w'ly el of Sect 26, 1651 sw disc gasser.	1- 9-48	8027	7366- 7370		F 60; 59 wtr; 1/8"	43.1
		TEXAS—District 3 (UPPER GULF COAST)—New Distillate Field						
Jefferson		McCarthy O&G Co's Mrs. W. H. Wood et vir 1, 660 fr n&wl of 160-ac lse in se¼ T&NO Sur, Sect 65, 2½ mi n of Hamshire, NW fld.	2- 6-48	11228	10446-10454	Frio sd; Olig	F 28; 2 wtr; 2.5 mln; ¼"	56.5
		TEXAS—District 4 (LOWER GULF-SW)—New Oil Pays						
Duval	Longhorn, S.	Hiawatha O&G Co's Leroy Denman A-2, 6100 fr el 2917 fr sl of 1061.1-ac "A" lse, Santos Garcia Gr. 1310 se of disc well.	2-24-48	5850	4195- 4200 5782- 5787	Cole sd; Eoc Hiawatha sd; Eoc	F 66; 5/32" F 88; 5/32"	42 45.6
Jim Wells	Premont, E.	Magnolia Pet Co's A. A. Seeligson III, 330 fr wl 3620 fr sl Jas. H. Houghton Sur, 4 mi nw Premont.	2-26-48	6114	4843- 4848	Zone 20 sd; Olig	F 68; 1/8"	36.8
Nueces	Farenthold	Jack Little, Trustee's W. F. Hackfeldt 1, 330 fr sl 467 fr el of 200-ac Tr in O. B. Carver Subd, Casa Blanca Gr. ½ mi m extension.	2- 1-48	5621	5604- 5607		F 29; 5/64"	
		TEXAS—District 4 (LOWER GULF-SW)—Oil Field Extension						
Duval	Peters, E.	Peters Bros' W. R. Peters 1-B, 660 fr el 1650 fr sl AB&M Sur, 320-ac lse. 1¼ mi s extension.	1-15-48	2737	2600- 2608	Mirando sd; Eoc	F 26; 3/16"	21
		TEXAS—District 4 (LOWER GULF-SW)—New Distillate Field						
Nueces		Producers Dev. Co. (was Tom Graham's) Louie Bailey 1, 330 fr s&el of Lot 15, Agua Dulce Fm lots. 1½ mi w Agua Dulce fld.	2- 4-48	6210	6148- 6158		no gge; 14.5 mln; open	58
		TEXAS—District 4 (LOWER GULF-SW)—New Gas Field						
Webb	Quien Sabe	O. W. Killiam et al's Marrs McLean 1, Blk 15, of Henry James Subd out of ne part of Las Albercas Gr, 6½ mi sw Bruni.	2- -48	2658	2314- 2316		no gge	
		TEXAS—District 4 (LOWER GULF-SW)—New Gas Pay						
San Patricio	Midway	F. M. Boykin et al's Doc Smith 2, (OWWO), 467 fr nl 1400 fr wl of ne¼ Sect 73, Geo. H. Paul's Subd of Coleman-Fulton Pastr Lds, on 100-ac lse.	2- 6-48	5736	3382- 3390		51.5 mln; open	
		TEXAS—District 5 (EAST CENTRAL)—Oil Field Extension						
Denton	Boliver	Placid Oil Co's W. E. Forester 2, 1264 fr nl 1982 fr el w. Nelson Sur, nw extension	2-10-48	1688	1670- 1688	Cisco sh; Penn	F 80; open	
		TEXAS—District 6 (NORTHEAST)—New Oil Pays						
Anderson	Blackfoot	Texas Company's R. F. Broadway 1, 660 fr n&el of 272-ac Tr & Jas. Welch Sur. 1375 s&w of disc.	2-21-48	9907	8972- 8992	Rodessa li; L. Cre	F 41; 5/16"	42
Harrison	Waskom	La Gloria Corp (was E. C. Johnston's) Smith & Lindsey 1, 5600 nw of sel 5280 ne of swl Simpson Holloway Sur.	1-21-48	6314	4930- 4965	Hill sd; L. Cre	F 58; ¼"	42.3
Wood	Yantis	Humble O&R Co's P. M. Rhodes et al 1, 3490 fr sl 1320 fr el Joshua Groce Sur, 1½ mi sw disc.	2-16-48	8250	4216- 4227	Eagleford sd; U. Cre	F 63; open	20.6
		TEXAS—District 6 (NORTHEAST)—Oil Field Extensions						
Harrison	Longwood, (Louisiana)	Sam E. Wilson Jr's Hearne Est B-1, 330 fr s&el of 180-ac Tr & F. C. Baker Sur. Extends Goodland prod into Texas.	2-12-48	5590	2340- 2360	Goodland li; L. Cre	P 30; 6 wtr	38.5
Harrison	Longwood, (Louisiana)	Arrow Drlg Co & Sella Pet Co's Mrs. Fannie Allen 1, 600 fr nl 700 fr el D. M. Evans Sur. Extends Travis Peak prod into Texas.	2- 8-48	6320	6093- 6105	Travis Peak sd; L. Cre	F 148; ¼"	42
		TEXAS—District 7-B (NORTH CENTRAL)—New Oil Fields						
Callahan		Al P. Groebe's Garland B. Gary 1, 3130 fr el 4100 fr nl W. H. Anderson Sur. 777. 2 mi se Cross Plains.	2-10-48	3682	3315- 3325	Strawn sd; Penn	P 124	44
Comanche		Coats and Foster Drlg Co's C. A. Scott 1, 440 fr wl 4250 fr nl of Wm. McClelland Sur. 2 mi e Comyn.	2- 2-48	4302	3526- 3528	Mississippi sd; Miss	P 10; 10 wtr	
Eastland		Bailey Griffen et al's C. M. McClelland 1, 2310 fr nl 2240 fr el Sect 463, SPRR Sur. 12 mi nw Cisco.	1-17-48	3671	3635- 3650	Caddo li; Penn	P 50	40
Nolan		Sohio Pet Co's Irl Faver 1, (OWDD), 661 fr nl 655 fr wl Sect 50, Blk 21, T&P Sur. 4 mi e Sweetwater.	2-21-48	6193	6147- 6193	Ellenburger li; Ord	P 183; 18 wtr	43
Throckmorton		Lloyd H. Smith et al's Hettie Ann List 1, 330 fr el 1100 fr sl Sect 2330, TE&L Sur. 8 mi se Throckmorton.	2-17-48	4670	4648- 4670	Mississippi li; Miss	P 14; 110 wtr	40
		TEXAS—District 7-B (NORTH CENTRAL)—New Gas Fields						
Brown		Central Texas Gas Co's Will Cason 4, 800 fr nl 2100 fr wl, J. M. Baker Sur. 2½ mi nw Thrifty.	1-22-48	2334	2315- 2334		5 mln	
Stephens		Texas & Pacific Coal & Oil Co's C. L. Trammell 1, 825 fr nl 1338 fr el Sect 42, Blk 8, T&P Sur. 6½ mi sw Breckenridge.	2-29-48	4415	4127		4.2 mln; 3/8"	
Stephens		Star Oil Co's Allar Co A-1, 1490 fr nl 467 fr el B. B. Stancel Sur. 7 mi s Woodson	2-25-48	4863	4328- 4332	Marble Falls li; Penn	100 mln; open	
		TEXAS—District 7-C (WEST CENTRAL)—New Oil Fields						
Crockett		Gulf Oil Corp's H. B. Cox Mineral Fee "C" 1, 3750 ne th 150 se of swc S. Sloan Sur 6. 2½ mi se Clara Couch fld.	1-18-48	1251	890- 915	Queen sd; Perm	P 152	26.8
Crockett	Tippett	Byrd-Frost's Mayberry 1 (OWWO), 330 fr ne&sel Sect 39, Blk 31, H&TC Sur. 6 mi sw Crockett fld.	2-14-48	7796	6320- 6325	Wolfcamp li; Perm	F 143; ¼"	54
		TEXAS—District 8 (WEST)—New Oil Fields						
Crane	"Gib"	Lion Oil Co's G. H. Cowden 1, 660 fr n&wl Sect 14, Blk X, CCSD&RGNG Sur. 4 mi sw Crane.	2- 3-48	8575	2735- 2775	Grayburg sd; Perm	P 20	29.4
Hale		Humble O&R Co's J. A. Lutrick 1, 660 fr sl 1980 fr el Sect 14, Blk D-8, EL&RR Sur. 6½ mi ne Abernathy.	2-22-48	7987	7910- 7987	Cisco li; Penn	F 162; ¼"	41
Howard	"Vealmoor"	Seaboard Oil Co's J. C. Caldwell 1-B (OWDD), 890 fr nl 2310 fr el Sect 32, Blk 32, T-3-N, T&P Sur.	2- 1-48	7974	7934- 7956	Pennsylvania sd; Penn	F 200; 5/16"	43.3
Scurry		R-Y Oil Co (was J. A. Robinson's) J. H. Taylor 1, 2310 fr s&el Sect 133, Blk 97, H&TC Sur. ½ mi nw Ira.	2- 1-48	3216	2973- 3176	Clear Fork li; Perm	P 88	25
Scurry		John Odstreil's O. Farrar 1, 330 fr s&el Sect 193, Blk 3, H&GN Sur. 2 mi s&e Sharon Ridge fld.	1-21-48	1714	1670- 1714	San Andres li; Perm	P 85	28
		TEXAS—District 9 (NORTH)—New Oil Fields						
Cooke		P. G. Lake, Inc's Pace Bros 2, 345 fr sl 1160 fr wl, M. R. Reek Sur. 4¼ mi w Wilson fld.	2-10-48	3003	2668- 2688		P 15; 5 wtr	
Montague		Kingery Bros Drlg Co's C. W. Rucktaskel 1, 5200 fr el 2000 fr sl Samuel Little Sur. 1 mi se Nocona, N. Shallow fld.	1-14-48	858	842- 858	Cisco sd; Penn	P 8	
Montague		Sinclair Prairie & Continental Oil Co's W. T. Minor 1-A, 467 fr nl 1000 fr el C. C. Milne Sur. 2 mi nw Montague.	2-16-48	6430	6182- 6254	Bend cgl; Penn	F 2832; 1"	40
Wichita		W. H. Hammon's G. M. Thaxton 1, 330 fr w&nel of farm in Blk 40, K&N Subd, Cherokee CSL Sur. 5 mi se Wichita Falls.	2-29-48	4477	4456- 4466		P 11	36
		TEXAS—District 9 (NORTH)—Oil Pay						
Clay	Acme	Superior Oil Co's Fred Wines et al 2, 990 fr nl 330 fr wl of farm or 2303 fr el 6750 fr nl of T. Morehead Sur. 2½ mi nw Deer Creek.	2-10-48	5867	5857- 5867	Mississippi li; Miss	F 372; 5/16"	41
		TEXAS—District 9 (NORTH)—Oil Field Extension						
Cooke	Wilson	Owen M. Murray (was Burk's) Fisher 1 (OWDD), 330 fr s&wl Jas. Hamilton Sur. 6 mi ne Gainesville, ne extension.	2-26-48	3047	3042- 3047	Strawn sd; Penn	P 82	32
		TEXAS—District 9 (NORTH)—New Gas Field						
Young		Star Oil Co's L. F. Evans, 330 fr n&wl Sect 1201, TE&L Sur. 3 mi n Eliasville	2-13-48	3395	3335- 3345	Caddo li; Penn	4 mln	
		WYOMING—New Oil Field						
Campbell		Texas Co's Unit 1, c nw ne 2-52n-72w, Adon Area, Powder River Basin	2- -48	9946	8997- 9012	Minnelusa sd; Penn	P 235	27
		WYOMING—New Oil Pay						
Sweetwater	Wertz Dome	Sinclair-Wyoming Oil Co's Unit 22 (OWDD), se se se 1-26n-90w	2-29-48	6635	6494- 6570	Darby sd; Penn	F 595	35
		WYOMING—Oil Field Extension						
Weston	Mush Creek	Texas Co's W. E. Updike 1, nw sw ne 21-44n-63w, 1½ mi s extension	2-21-48	4275	4227- 4237	Newcastle sd; U. Cre	P 55	

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formations abbreviated thus: Plio, pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hr. rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.

Prevention of Drill String Failures in the Permian Basin

DRILL STRING research, sponsored by the American Association of Oilwell Drilling Contractors and carried out at Battelle Memorial Institute, developed causes which contributed largely to the high percentage of failures when drilling in the Permian Basin of West Texas. The author summarizes the methods followed in the research and offers conclusions based on observed results.

By ROBERT C. McMASTER
Battelle Memorial Institute

Part 1

DRILL string failures in the hole were a major problem in the Permian Basin oil fields two years ago. Washouts and twistoffs occurred so frequently that they significantly increased drilling costs, not only through drilling time lost and expensive fishing jobs, but also by shortening the safe operating life of the drill string. Failures were not limited to particular operators or drilling conditions, but were general throughout the Permian Basin region (Figure 1). The cause of the frequent failures was not generally known. They were blamed upon "war pipe," deeper drilling, mechanical damage, and similar causes. The operators had no effective means of preventing frequent failures, or of increasing the operating life of drill strings.

Drilling in this area required rockbits throughout. Ten thousand-foot holes were common. Salt beds were encountered from about 1700 to 3800 feet. Brine was used as a drilling fluid in the salt sections in order to avoid undue enlargement of the hole.

Similar drill strings, operating under what appeared to be practically identical conditions, behaved differently. Some strings of pipe deteriorated so rapidly that they had to be discarded before the first well had been completed. Other strings drilled 50,000 or more feet of hole. There apparently was no evidence that pipe of higher tensile strength gave any better performance than the common grade. The difficulty encountered was not confined to pipe produced by any one manufacturer; similar trouble was experienced with pipe made by all of the drill-pipe manufacturers.

Causes of Drill-Pipe Failures

Careful examination of typical drill-pipe failures in the field and in metallurgical laboratories revealed that in many cases the deterioration started on the inside surface of the drill pipe and progressed very rapidly as a result of intense corrosive action. The corrosion was especially severe on the inside surface. It produced deep corrosion pits (Figure 2), that concentrated the repeated stresses during drilling. These nuclei resulted in the formation of fatigue cracks because of the repeated stressing (Figure 3). Accelerated by further corrosive attack, these fatigue cracks propagated transversely around and through the wall of the pipe (Figure 4), ultimately resulting in failure. When the fatigue crack had penetrated completely through the pipe wall, a washout occurred (Figure 5). Abrasion then rapidly enlarged the hole and tended to cut off the drill pipe. Repeated stressing of the remaining reduced section usually caused a "twistoff" in the hole (Figure 6).

Other drill-pipe failures were traced to external causes, such as mechanical damage to the outer surface of the drill pipe, or unreasonable overloading. The portion of the drill pipe within six feet of the tool joint suffered most severely as a result of the action of slips and tongs (Figure 1). The mechanically formed marks and grooves were nuclei from which fatigue cracks propagated just as they propagated from the corrosion pits on the internal surface of the pipe (Figure 7). In general, abrasion of the outside surface of the pipe against the hard rock wall of the hole removed the products of corrosion along the center of each joint so that few corrosion pits developed to serious dimensions in this area. Such wear of the external surface of the pipe contributed to wall thinning, of course, which in time

FIGURE 1. Portion of a drill string observed in the Permian Basin in 1945. The white chalk marks show the location of large transverse cracks on the box end of the joints.

FIGURE 2. Typical corrosion pits in drill pipe from Permian Basin.

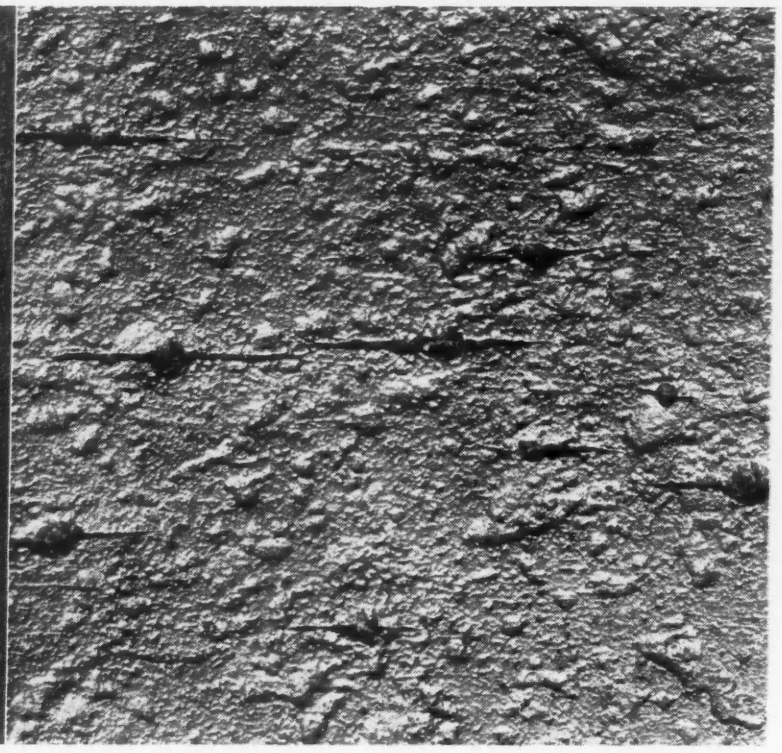


FIGURE 3. Transverse fatigue cracks developing from corrosion pits, after repeated stressing of drill pipe.

might cause static failure under excessive loading.

Mechanism of Drill-Pipe Corrosion

The surface of drill-pipe steel, even after careful cleaning, is usually covered by an air-formed oxide film which may or may not be invisible. Many weak spots exist in such films, particularly in the areas of heterogeneity. When the steel is immersed in brine or a conducting drilling fluid, these corrodents attack the oxide films and the metal begins to corrode at the weak spots. These become anodes and electric current flows from them to the less easily attacked zones, which form the cathodes of the corrosion cells. As corrosion progresses, the corrosion products may stimulate further attack. The oxide film possesses no powers of self-healing except when strong oxidizing agents, such as chromate, are present. In the absence of chromate, such oxide films offer no useful protection against solutions containing anions with strong penetrative powers, such as the chlorine anion of brine. In fact, films of this type often serve to intensify attack after penetration has occurred, because of the cathodic nature of an oxide-covered surface as compared with one free from oxide.

When steel drill pipe is exposed to sodium chloride brine, ferrous chloride is formed at the anodes. Hydrogen and sodium hydroxide are the primary ca-

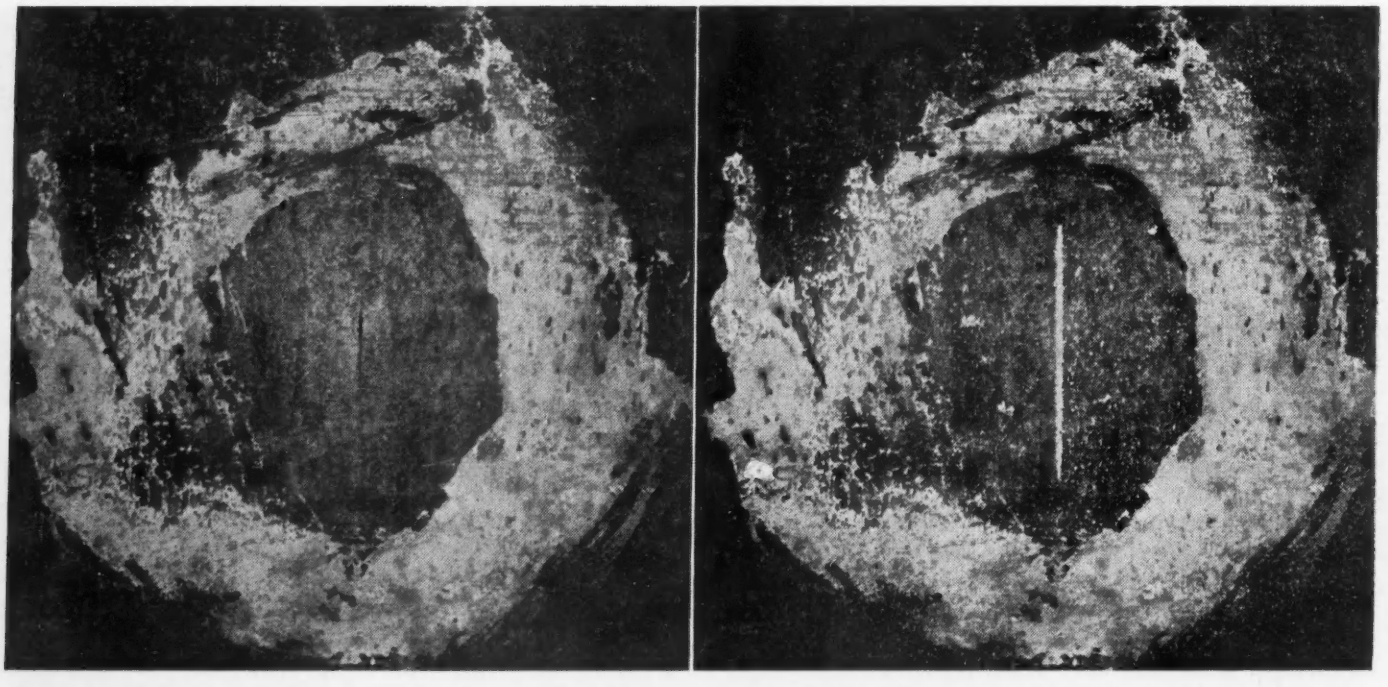


FIGURE 4. Fatigue crack which has propagated from internal corrosion pits through wall to outer surface of drill pipe. Left: Crack through pipe wall, as seen by unaided eye. Right: Magnaflux indication showing extent of crack pictured at left.

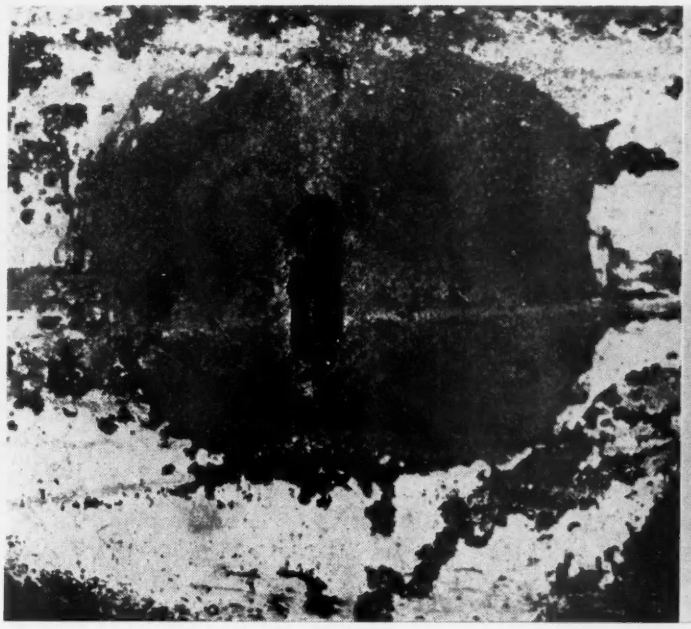


FIGURE 5. Washout after fatigue crack had penetrated through wall of drill pipe.

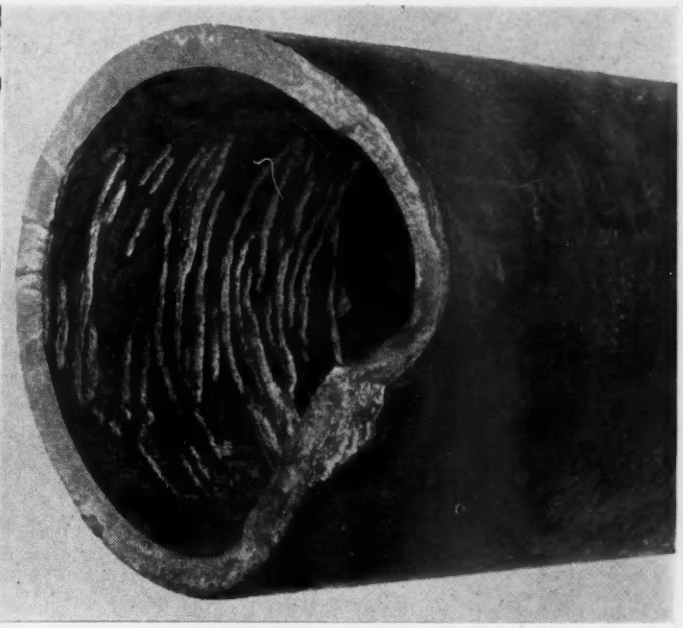


FIGURE 6. "Twistoff" following severe internal corrosion of drill pipe. Deep fatigue cracks were found in each corrosion groove.

thodic products. Ferrous hydroxide is formed as a precipitate from the soluble reaction products. The ferrous hydroxide reacts with oxygen dissolved in the brine to form a hydrated form of magnetite, Fe_3O_4, which usually oxidizes to form rust.

The hydrogen formed at the cathodes polarizes them and retards the reaction in nonagitated solutions. It opposes the metal solution potential of the iron with the higher solution potential of atomic hydrogen. The dissolved oxygen in the brine serves to remove the hydrogen layer. Therefore, corrosion proceeds at a rate determined by the supply of oxygen to the cathodic areas. In very concentrated salt solutions the total corrosion is considerably reduced because such solutions have reduced solubility for oxygen. Circulation of brine solutions may tend to wipe off the polarizing layer of hydrogen, thus increasing the corrosion rate. Many Permian Basin drilling conditions contribute to very severe corrosive attack of drill-pipe steel, by stimulating the rates of these reactions.

Corrosion-Fatigue Properties of Drill-Pipe Steel

The problem of corrosion fatigue failures of steel was studied extensively in research laboratories. These studies indicated that economically practical changes in the metallurgy or physical properties of the steel used in drill pipe could not make a significant improvement in performance under corrosion fatigue conditions. High-tensile steel and low-carbon steel showed almost identical strengths and lifetimes under repeated loading when subjected to the corrosive action of brine. Consequently, the most profitable approach to a solution of the drill pipe problem appeared to be in the direction of reducing or preventing corrosion. By reducing corrosion, very large improvements in the performance of the drill string might be attained at a reasonable cost. It was recognized, of course, that under drilling conditions, it probably would not be possible to prevent corrosion completely. Instead, it was necessary to evaluate the relative merits of various procedures for reducing corrosion. It was obviously impractical to carry out under field conditions, where a test might last for six months or a year, comparative measurements of various corrosion preventive techniques. Under field operating conditions the influence of other variables such as rate of drilling and drilling techniques, might influence the results so that no clear-cut analysis could be made.

Laboratory Tests

Extensive laboratory tests were made of each of the practical methods of improving the operating life of the drill string under corrosive brine conditions. Small steel rotating beam fatigue test specimens (Figure 8) were subjected to accelerated corrosion conditions, and loaded repeatedly at a speed of nearly 100,000 cycles per hour (Figure 9). The test conditions were selected so that

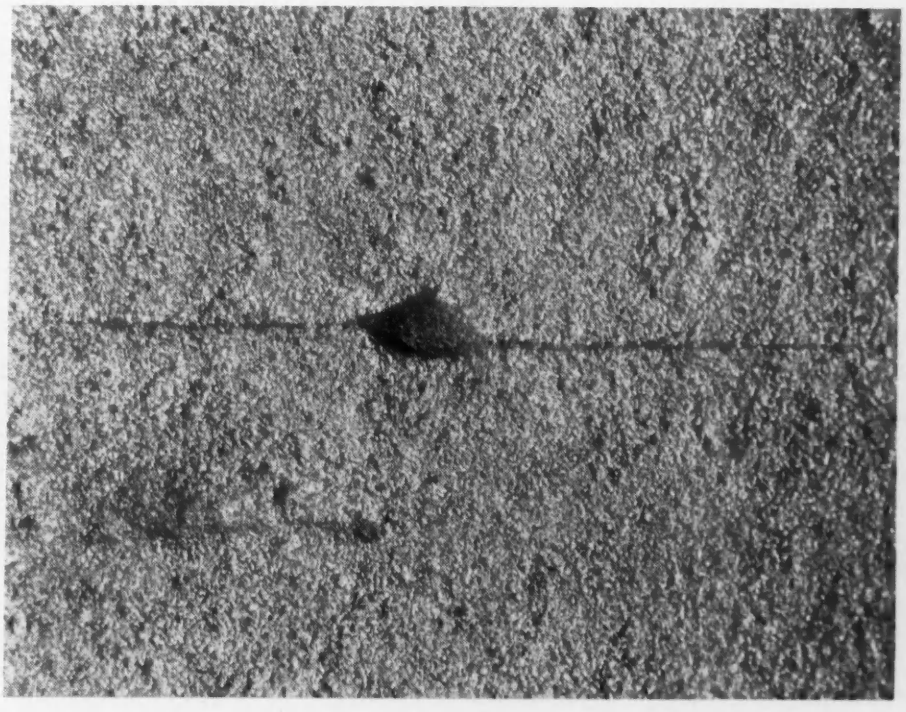


FIGURE 7. Fatigue cracks propagating from sharp corners of an external surface "nick."

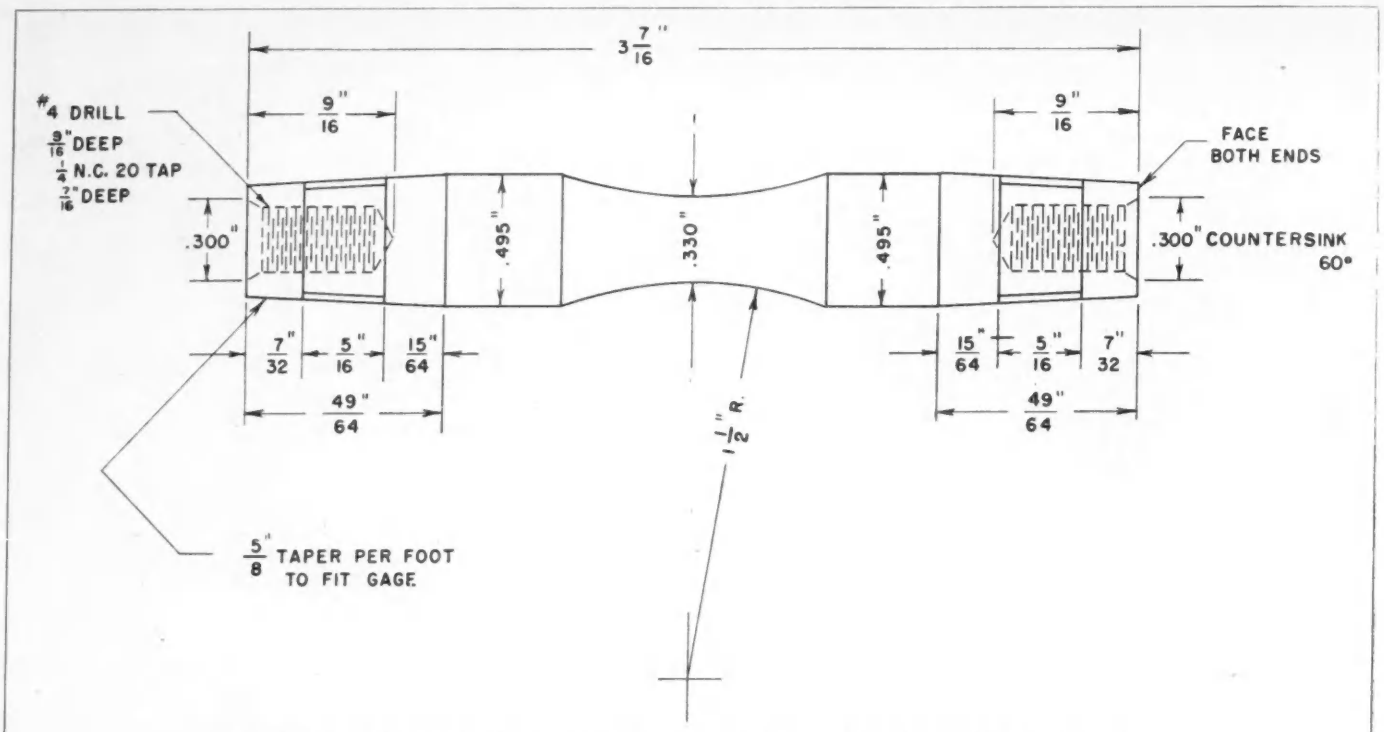


FIGURE 8. Small rotating beam test specimen used for accelerated corrosion fatigue tests.

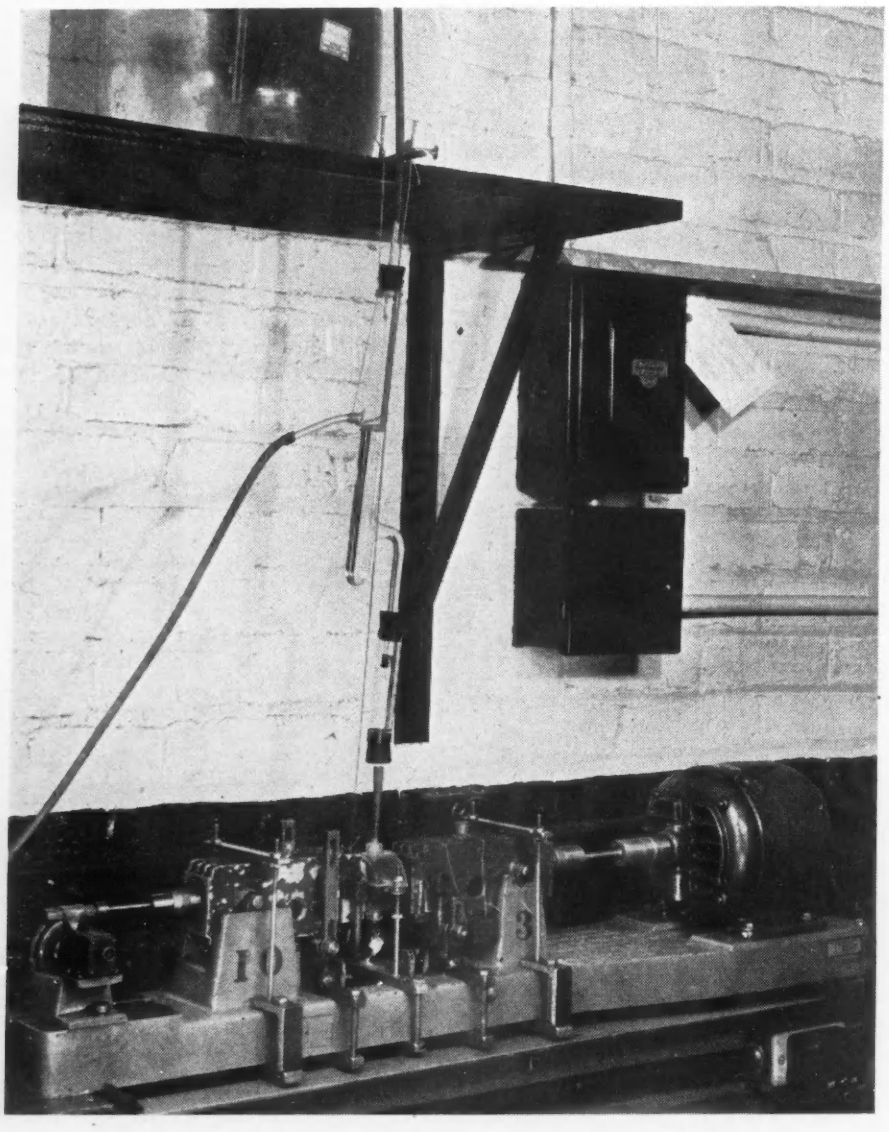


FIGURE 9. Equipment for accelerated corrosion-fatigue testing.

corrosion pits, fatigue cracks, and failures (twistoffs) were obtained in the test specimens which had every feature characteristic of those on used drill pipe, but on a smaller dimensional scale (Figure 10). The actual operating lifetimes obtained under these test conditions with small specimens proved to be identical with the first results reported from long-time slow-speed full-scale laboratory corrosion fatigue tests of a joint of drill pipe (Figure 11). The laboratory tests were rapid, economical, and permitted more precise control than full-scale field tests, so that extensive data were obtained during a year's research. The results predicted from these small-scale tests have since been verified by operating experience in the Permian Basin.

Operating Stress

The tests showed that repeated-load operating lifetime under severe corrosion conditions was greatly increased by reducing the stress applied to the steel. The stress-cycle (S-N) curves (Figure 11) for bare specimens indicated that steel equivalent to Grade D pipe, could not be made to fail in air in the absence of corrosion even in 10 million cycles of reversed stress below the endurance limit of 47,000 pounds per square inch. The specimens tested under severe corrosion conditions would fail at any stress (Figure 11). However, the corrosion fatigue operating lifetime could be increased ten times (from 420,000 to 4,200,000 cycles) by reducing the operating stress from 40,000 to 20,000 psi. Overloading to 60,000 psi (as might occur when drill strings are operated in

compression) reduced the operating life to 1/10 (42,900 cycles) of the life at 40,000 psi. The laboratory tests indicated that differences in operating lifetimes of the order of 100 to 1 are possible simply as a result of a change of the order of 3 to 1 in the stress applied to the steel.

Observations in the field revealed that the largest stresses applied to the drill strings occur when the drill string is operated in compression. Under compression, the column of pipe had a tendency to bend or "dog-leg" in the hole. The stresses produced by the bending of the column of the drill string far exceed those stresses developed by the torque applied to the bit. When long strings of drill collars were employed to provide the weight on the bit and to keep the entire drill string in tension, the repeated bending stresses were greatly reduced. Consequently, drill collars in numbers sufficient to keep the entire drill string in tension were recommended also as a means of prolonging the performance of the drill string. The use of long strings of drill collars was not without its disadvantages, however. First, the drill collars were expensive and represented a sizable investment. Secondly, the speed of the rotation was usually reduced to about 50 to 60 revolutions per minute in order to prevent mechanical failures in the collars. Third, it was found that extremely difficult fishing jobs could result from the sticking of the drill collars in the hole. This was especially true if the collars were so large with respect to the hole size that it was impossible to wash over the stuck collars. Despite these minor disadvantages, long strings of drill collars are now used extensively in the Permian Basin oil fields, with consequent improvement in drill-string performance.

FIGURE 10. Multiple fatigue cracks and twist-offs in bare specimens tested in the standard test corrodent.

Protective Coatings

The laboratory corrosion fatigue tests demonstrated that protective coatings, which completely protect all surfaces of the steel from corrosive attack, can greatly prolong the operating life under corrosion-fatigue conditions. So long as the coating remains intact and impervious to the corrodent, the steel may be operated below the endurance limit for an indefinitely prolonged lifetime (Figure 12). When the coating fails or is finally penetrated by the corrodent, the normal corrosion fatigue lifetime still remains available in the steel (Figure 13). The laboratory tests indicated that, at a repeated stress of 40,000 psi, the lifetime of the specimens might be increased as much as 150 times by the use of zinc plating or multilayer plastic coating systems. The full benefits of plastic coatings were obtained when the steel was protected by a properly designed multicoat system which provided good adhesion and chemical protection in the primer layers. The outer layers provided resistance to abrasion and to chemical attack. Even in the presence of alkali, such as 2 percent of sodium hydroxide, both the zinc plating and the plastic coating system survived for indefinite operating lifetimes.

Unfortunately, in drill-pipe applications, the plastic coating can be maintained only on the inside surface of the pipe. Abrasion of the pipe against the hard rock of the hole quickly removes any coating from the outer surface. However, plastic or zinc coating of the inside surface of drill pipe provides significant protection, since the field observations indicated that most failures propagated from corrosion pits on the internal surface.

Plastic-coated drill pipe has been made available by drill-pipe manufacturers, and services for the plastic coating of drill pipe have been established in the field. Operating experience in the Permian Basin indicates that plastic-coated pipe often outlived uncoated pipe by three to four times normal lifetime. When such joints were finally removed

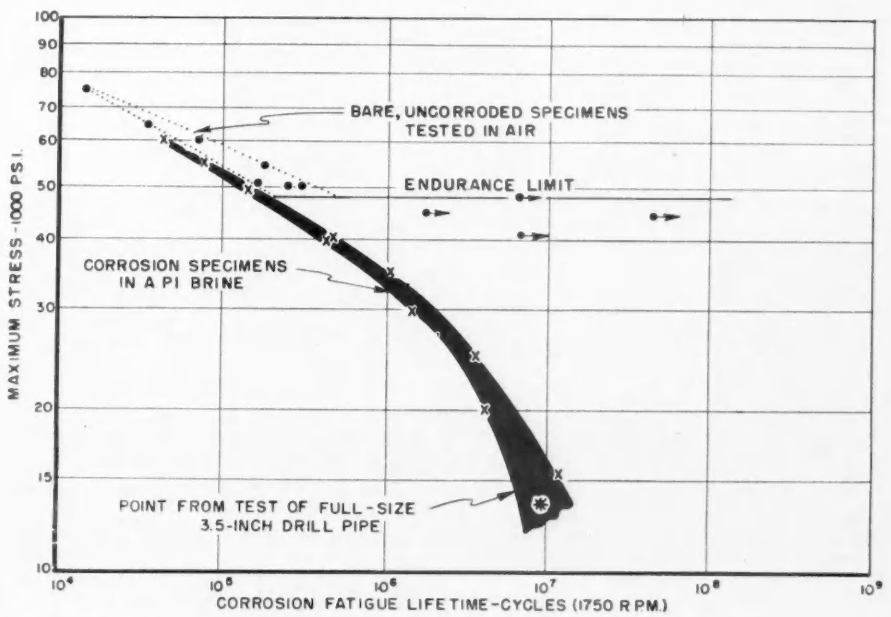


FIGURE 11. Stress-cycle data for bare specimens tested in air and in the standard corrodent.

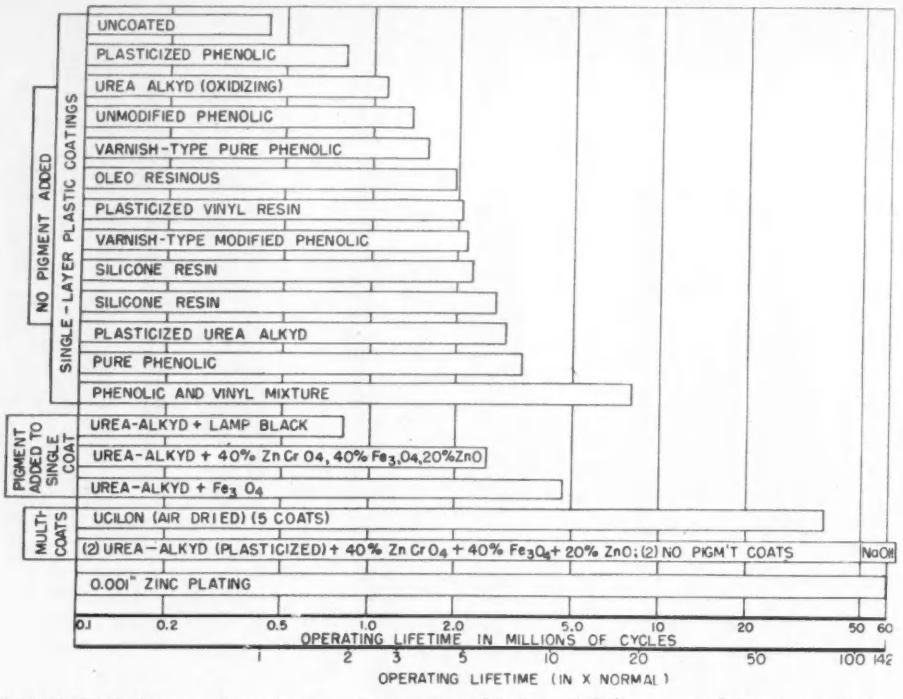

NO PIGMENT ADDED
SINGLE-LAYER PLASTIC COATINGS
UNCOATED
PLASTICIZED PHENOLIC
UREA ALKYD (OXIDIZING)
UNMODIFIED PHENOLIC
VARNISH-TYPE PURE PHENOLIC
OLEO RESINOUS
PLASTICIZED VINYL RESIN
VARNISH-TYPE MODIFIED PHENOLIC
SILICONE RESIN
SILICONE RESIN
PLASTICIZED UREA ALKYD
PURE PHENOLIC
PHENOLIC AND VINYL MIXTURE
PIGMENT ADDED TO SINGLE COAT
UREA-ALKYD + LAMP BLACK
UREA-ALKYD + 40% ZnCrO4, 40% Fe3O4, 20% ZnO
UREA-ALKYD + Fe3O4
MULTI-COATS
UCILON (AIR DRIED) (5 COATS)
(2) UREA-ALKYD (PLASTICIZED) + 40% ZnCrO4 + 40% Fe3O4 + 20% ZnO; (2) NO PIGM'T COATS
NaOH
0.001" ZINC PLATING
0.1 0.2 0.5 1.0 2.0 5.0 10 20 50 60
OPERATING LIFETIME IN MILLIONS OF CYCLES
1 2 3 5 10 20 50 100 142
OPERATING LIFETIME (IN X NORMAL)

FIGURE 12. Influence of coatings on the operating lifetime of drill pipe steel in corrosive brine.

from service because of failure of the coating, the steel beneath the coating was still bright and clean even in areas where the coating had fractured. Some joints of this type were then cleaned and recoated with plastic, and continued to give excellent service until damage of the external surface required their retirement. It has not yet been determined definitely whether it is essential to use plastic coated drill pipe for the entire drilling operation, or if it is necessary only while drilling the salt sections.

Chemical Inhibitors

As an alternative to coating the surface of the drill pipe, chemical inhibitors may be added to the drilling fluid. These inhibitors act to protect the outside as well as the inside surface of the pipe. In addition, they are beneficial to the threads, tool joints and mud pumps.

Soluble chromates inhibit corrosion by keeping the primary oxide film in a state of good repair; that is, they serve as anodic inhibitors. Ferric and chromic oxides are precipitated by the chromate and form protective films at the weak points in the film. Insufficient concentrations of sodium chromate may increase the intensity of corrosion by blanketing out most, but not all, of the potentially anodic areas, so that the corrosive attack is concentrated at the few which remain. If sodium chromate is present in sufficient concentration, the control reverts from cathodic to anodic and the intensity of corrosion decreases. Consequently, the effectiveness of sodium chromate additions to drilling fluids depends upon the concentration of the additions, and upon the operating conditions. Partial protection, giving only minor or irregular improvements in operating life, may be anticipated with excessively low concentrations of sodium chromate.

Laboratory corrosion fatigue tests indicated that varying the sodium chromate concentrations significantly influenced the operating life in brine at 40,000 psi stress (Figure 14). Normal lifetime at this stress was about 400,000 cycles, in the absence of inhibitors. The operating lifetimes of the small steel specimens were more than doubled by additions of 0.25 percent or more of sodium chromate. However, wide scatter appeared in the test results for sodium chromate additions in the range from 0.1 to 1 percent concentration. Lifetimes varying irregularly from 1 million to 2½ million cycles occurred anywhere in the sodium chromate concentration range from 0.4 to 1 percent. Such results might be expected if the sodium chromate additions were providing only partial protection. However, a scatter of the order of 2½ to 1 is not unusual in normal fatigue operating lifetimes in the absence of corrosion. High sodium chromate concentrations, say 10 percent, produce large improvements in operating lifetimes, of the order of ten times normal life without the inhibitor. Such concentrations are obviously not economically practical for drilling muds.

Sodium chromate is typical of several other chemical inhibitors which gave partial corrosion protection. None of the chemicals tested gave complete protection when used in concentrations under 1 percent, although, in this range, sodium chromate or sodium phosphate gave the greatest improvement in operating life.

In contrast with these results, complete protection from corrosion was attained by the addition of 2 percent or more of sodium hydroxide (Figure 15). The complete protection was made evident by the fact that specimens operated at 40,000 psi for lifetimes of more than 20 million cycles without failure and with no evidence of corrosion. The use of such concentrations of caustic is impractical in drilling because the caustic reacts with the magnesium and calcium salts to form insoluble precipitates, and it floccu-

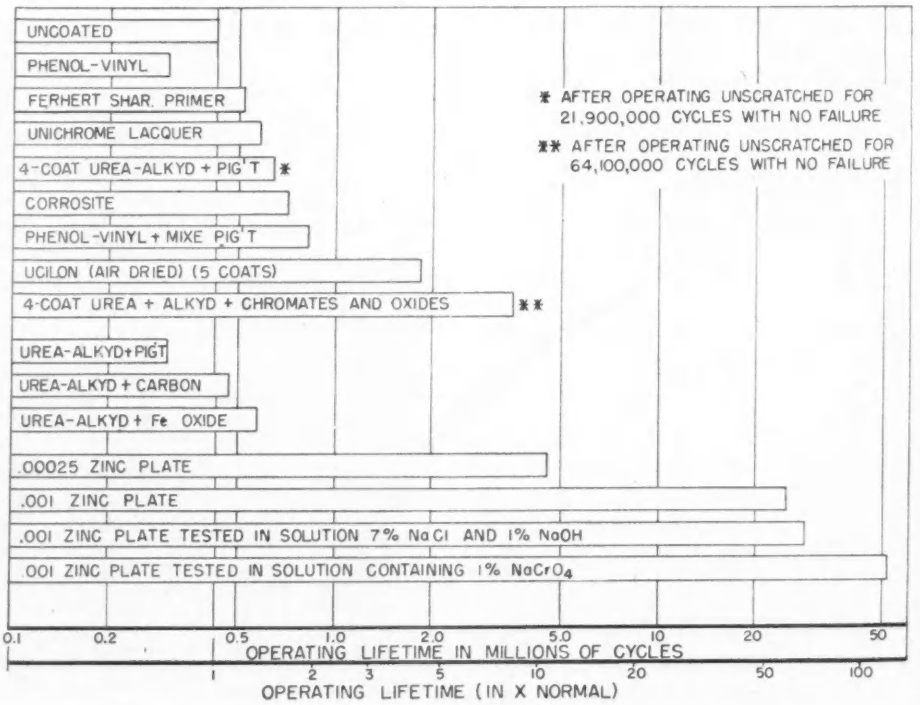
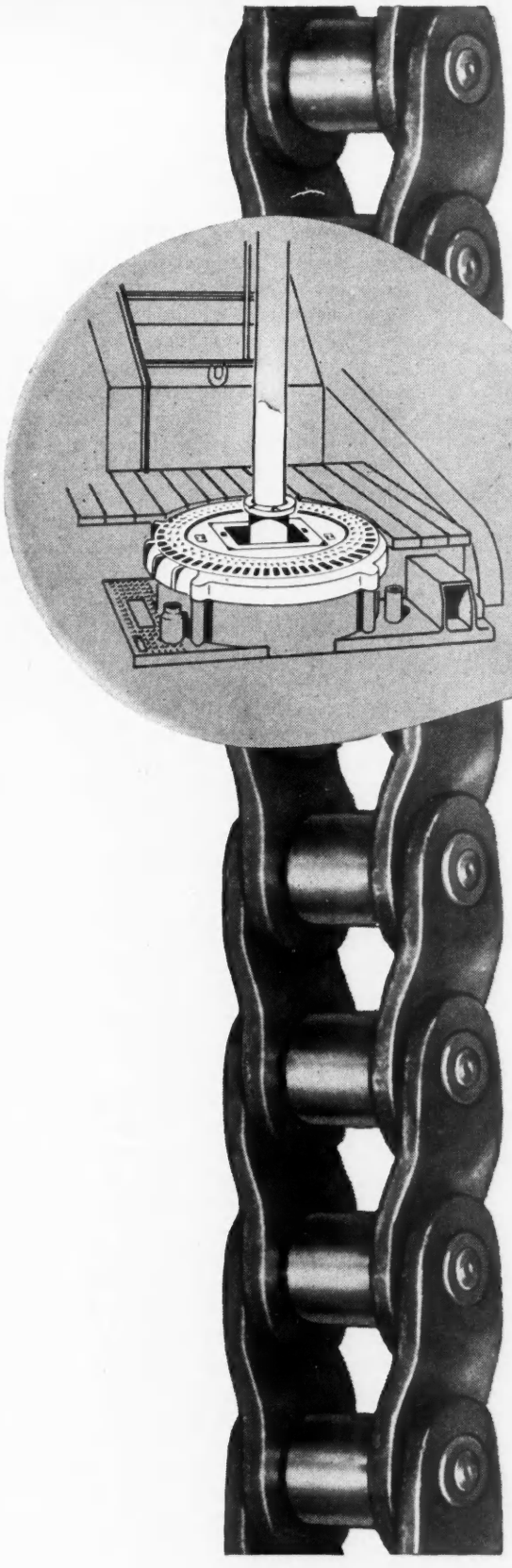

UNCOATED
PHENOL-VINYL
FERHERT SHAR. PRIMER
UNICHROME LACQUER
4-COAT UREA-ALKYD + PIG'T *
CORROSITE
PHENOL-VINYL + MIXE PIG'T
UCILON (AIR DRIED) (5 COATS)
4-COAT UREA + ALKYD + CHROMATES AND OXIDES **
UREA-ALKYD+PIGT
UREA-ALKYD + CARBON
UREA-ALKYD + Fe OXIDE
.00025 ZINC PLATE
.001 ZINC PLATE
.001 ZINC PLATE TESTED IN SOLUTION 7% NaCl AND 1% NaOH
.001 ZINC PLATE TESTED IN SOLUTION CONTAINING 1% NaCrO4
* AFTER OPERATING UNSCRATCHED FOR 21,900,000 CYCLES WITH NO FAILURE
** AFTER OPERATING UNSCRATCHED FOR 64,100,000 CYCLES WITH NO FAILURE
0.1 0.2 0.5 1.0 2.0 5.0 10 20 50
OPERATING LIFETIME IN MILLIONS OF CYCLES
1 2 3 5 10 20 50 100
OPERATING LIFETIME (IN X NORMAL)

FIGURE 13. Influence of scratched coating upon the operating lifetime.



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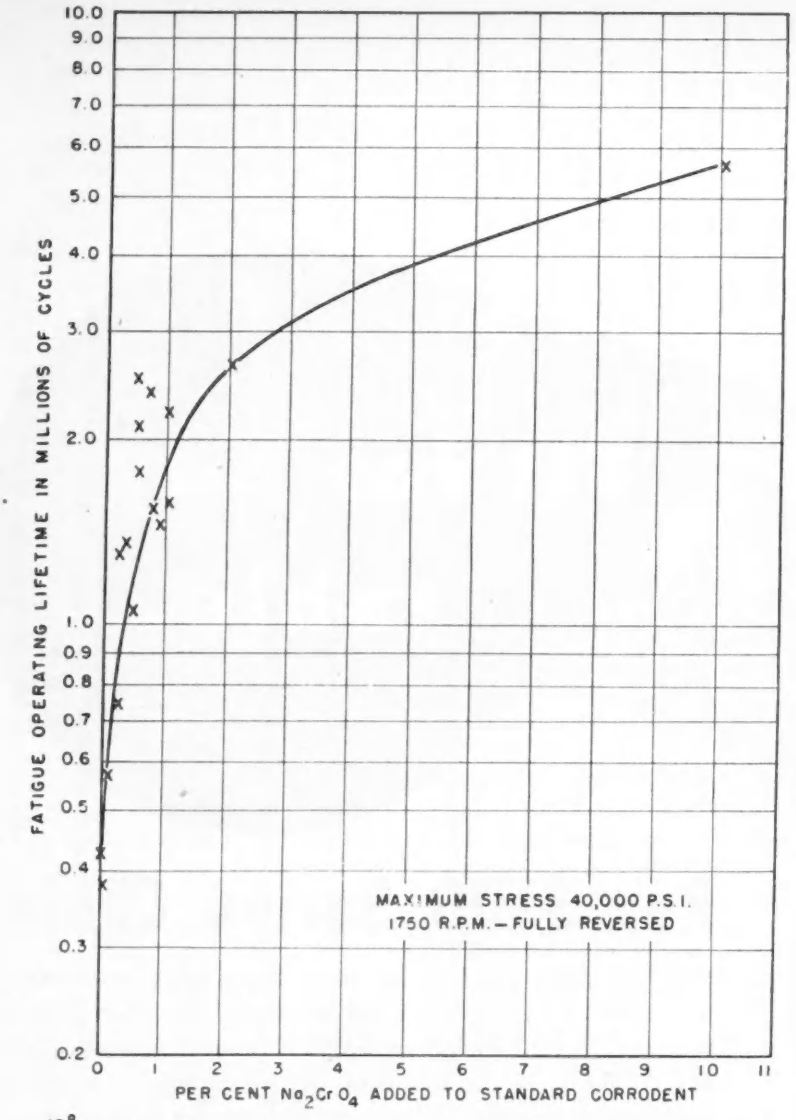
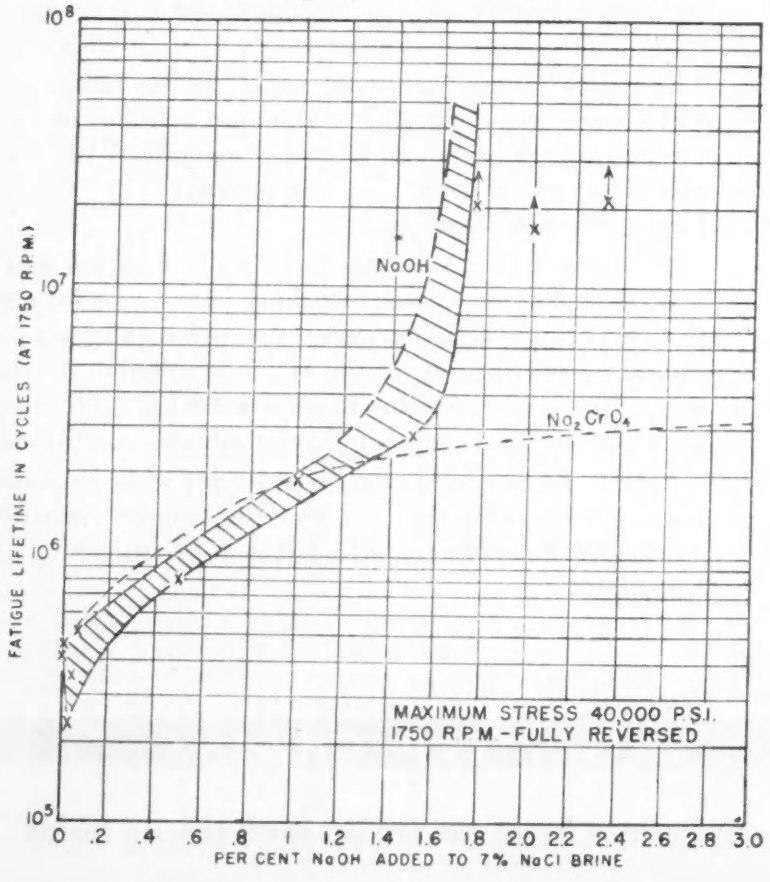

FATIGUE OPERATING LIFETIME IN MILLIONS OF CYCLES
MAXIMUM STRESS 40,000 P.S.I.
1750 R.P.M. — FULLY REVERSED
PER CENT Na_2CrO_4 ADDED TO STANDARD CORRODENT


FATIGUE LIFETIME IN CYCLES (AT 1750 R.P.M.)
NaOH
Na_2CrO_4
MAXIMUM STRESS 40,000 P.S.I.
1750 R.P.M. - FULLY REVERSED
PER CENT NaOH ADDED TO 7% NaCl BRINE

lates the drilling muds. However, these tests demonstrate clearly that the sodium chromate additions, although optimum among practical chemicals tested to date, do not provide complete chemical protection against drill-pipe corrosion.

From these tests, it appeared that additions of sodium chromate would be relatively ineffective unless combined with other good drilling practices. For example, the use of sodium chromate additions may produce added benefits from the use of long strings of drill collars to reduce the bending stresses in the drill pipe. The lower the operating stress, the greater these benefits are. For example, it was observed previously that, in the absence of chromate, reducing the operating stress by 20,000 psi increased the corrosion fatigue operating life by a factor of about ten times. With 1 percent sodium chromate, the corrosion fatigue operating lifetime increased by a factor of about 100 when the operating stress was reduced by 20,000 psi and chromate added.

At 40,000 psi, the operating lifetime was increased to about five times the normal operating lifetime, when sodium chromate was added. At 30,000 psi, a life of more than 46 million cycles was obtained without failure. This lifetime was nearly 30 times greater than the normal lifetime at this stress in the absence of chromate, and more than 100 times greater than the lifetime at 40,000 psi in the absence of chromate. The sodium chromate additions, therefore, added considerably to the benefits to be obtained by reducing the operating stresses.

Similar benefits may be obtained when sodium chromate additions to the drilling fluids are used with internally coated drill pipe. The chromate provides added protection to the steel after the coating has been scratched through, or has flaked off the pipe surface. Tests with scratched zinc-plated specimens with 1 percent sodium chromate added to the corrosive brine, indicated that the operating life was twice that obtained with similarly scratched specimens in brine without the chromate additions (Figure 13). Similar results may be obtained with plastic coated pipe. It appears, therefore, that sodium chromate may be used with coated drill pipe to provide protection to the outside surface which is not coated, and to prolong the operating life after the internal surface coating fails.

FIGURE 14 (above). Increase in operating lifetime caused by adding sodium chromate to brine corrodent.

FIGURE 15 (below). Increase in operating lifetime caused by adding sodium hydroxide to brine corrodent. (Curve for sodium chromate addition is shown dotted, for comparison.)

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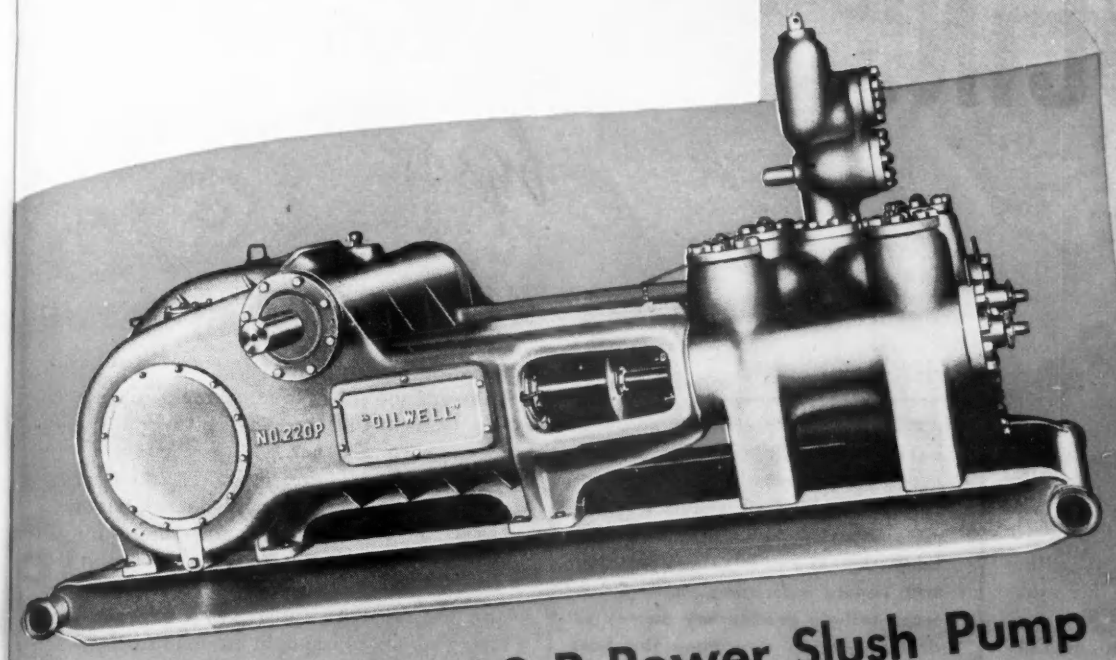

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REDUCING Drilling Expenses by

By GLEN D. HUGHES
Sun Oil Company

PRESENT conditions place a premium on speed in drilling operations. In order to maintain this speed with safety the operator should, if possible, standardize his rigs and take advantage of any improvements that will reduce operating time. Other steps include preliminary survey of drilling site to determine the best entrance and position for the rig; measures to protect equipment from damage in moving; convenient rig layout, etc. Such steps require extra consideration but in the long run will pay dividends in time and money saved.

WITH ever-increasing emphasis on speed and economy in drilling operations, it has become necessary to give more thought to the design and layout of drilling rigs. Formerly very little consideration was given to time and material saving in setting up a drilling rig or the dismantling of a rig for moving to a new location.

Costs of labor and equipment certainly preclude this complacent attitude if drilling operations are to be profitable for the operator. There are many and various ways to eliminate lost time and decrease maintenance cost in drilling operations, a few of which will be discussed in this paper. It is to be borne in mind that this discussion primarily concerns the heavier drilling rigs; however, it is believed that it will apply equally well to the lighter units.

An operator with more than one rig should strive to standardize his equipment as nearly as possible. This will reduce operating cost by reducing the amount of surplus parts to be carried in stock. Also by standardizing his rigs the operator will be able to transfer his crews from one rig to the other without much lost motion.

Transporting Drilling equipment

The primary concern of the operator in transporting drilling equipment should be to have sufficient racks to accommodate the smaller articles of equipment such as tongs, elevators, slips, rotary hose, etc. The most effective way to shorten the life of a rubber rotary hose is to have it thrown on top of a load of other equipment and then bound down, or to pick it up in the middle with a winch line. This procedure breaks down the walls of the hose.

To eliminate possible damage to rotary hose, a rack approximately 7x14x3 feet should be constructed from discarded four-inch drill pipe, with guides of 2½-inch pipe welded inside in an upright position and approximately 12 inches from the main body of the rack. This type of rack will permit the hose to be taken down and coiled in the rack, all in one operation. The area inside the coil of rotary hose affords a very convenient place to transport the small articles of equipment usually found on a derrick floor, such as tongs, slips, elevators, etc.

Racks also should be provided for water lines, mud lines and the extra pipe usually carried with the rig. A well-planned and designed set of racks for a rig will eliminate considerable unnecessary expense, notably the necessity for the crews to spend time looking for various tools and equipment when setting up the unit, and will minimize damage and loss of equipment during the transporting of the rig from one location to another.

When the location is staked, the tool pusher or drilling superintendent should check the drilling site immediately for the most convenient way to get to it, the location of slush and reserve pits and the most desirable way to face the rig. This survey should be made before any equipment is moved to the new location. Often a little time spent checking all the available entrances to a drilling site will save many dollars in transportation expenses.

When the drill site is level, slush and reserve pits present no problem. However, when the terrain is rough, considerable thought should be given to their location to avoid time consumed in the moving of unnecessary dirt. Whether the terrain is rough or level, the reserve pit should be constructed so that the side next to the slush pit is the lowest side. This will facilitate adding new mud to the circulating system when it becomes necessary.

When pits are constructed for deep wells it is always wise to have a partition built in them. The smaller side is for shale and sand while the larger is for the native mud made while drilling. This arrangement will make available at all times a good clean supply of mud for adding to the system. It is difficult

About the Author

GLEN D. HUGHES was born at San Antonio and graduated from Texas A & M College in 1934, after which he joined Sun Oil Company and worked in the oil fields as roustabout, roughneck and oil scout. In 1939 he was transferred to the Texas Gulf Coast where he pushed tools until 1942, when he was granted a military leave of absence and joined the Field Artillery, participating in the European theater. He was discharged in 1946 with the rank of major and returned to Bay City, Texas, as drilling superintendent, but shortly afterwards was transferred to Tulsa, where he is now Sun's Mid-Continent production division superintendent.

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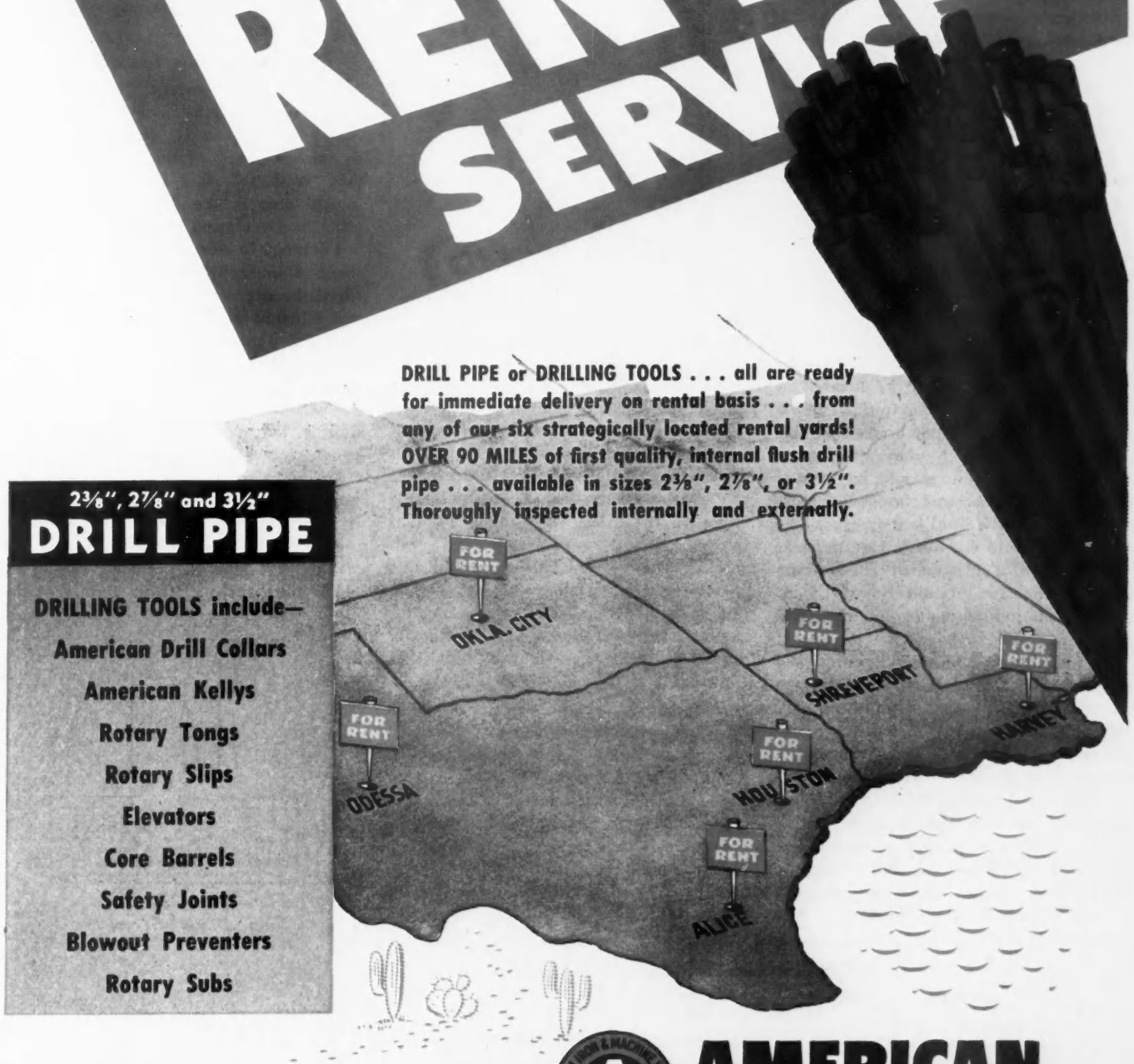

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to estimate the size of reserve pits necessary for a well in new territory; however, after the first well is drilled, the pit should be decreased or increased in size to fit the existing conditions.

The direction as rig is faced is an important matter that is often neglected. Obviously it is not good practice to face a rig north in the winter when it could just as easily be faced south. The efficiency of the drilling crews is not as high as it should be when they are offered no protection. Likewise, it is not good practice to face the rig to the west in the summer so that the sun shines in the driller's eyes all afternoon. The rig should be faced so that the driller will have maximum vision at all times.

The rig should be so located on the drill site that the pipe racks will be readily accessible to the entrance chosen. If this is not done, much time and expense may be consumed in the unloading of drill pipe, casing and tubing.

General Layout for Rig

There are many different ways to put a rig together; consequently, no set plan will be given, but only a few principles that should be kept in mind.

On a well where it is anticipated that commercial mud will be used, the mud house and hopper should be located in such a place that mud material can be delivered directly to the house and not have to be carried by hand for some distance. The hopper should be located at the end of the mud house opposite the one where the mud is delivered. The mud gun should be located at or near the point of discharge of the mixing hopper. The gun should be well constructed of good fitttings and pipe and well tied down.

In addition to commercial muds and weight materials, various chemicals for the control of the viscosity, water loss, pH, etc., are required. This is an expensive process at best; consequently, a little time spent in preparing for its use will pay dividends. When the various chemicals are delivered to the rig, a good dry place such as the mud house should be available for their storage. Next, there must be a satisfactory method of adding the chemical to the mud stream. Many operators go to the expense of having chemical tanks made and mounted on skids but a 55-gallon oil drum usually will serve the purpose. A chemical tank can be constructed easily from an oil drum by cutting the bottom out, and screwing a short 2x1-inch swage in the two-inch outlet in the top of the drum. Put a one-inch gate valve on the swage and then screw as long a nipple as necessary in the other side of the valve. The one-inch gate valve is desired because when it becomes plugged with chemical it can be cleaned easily. A high pressure supply of water should be near the chemical tank. See Figure 1.

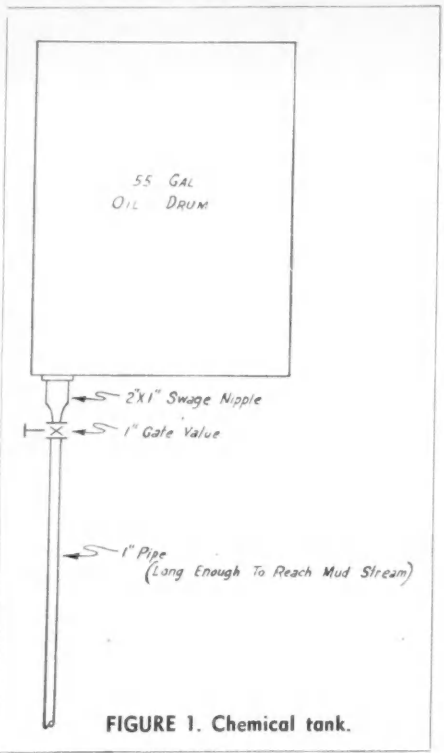


FIGURE 1. Chemical tank.

To properly mix the dry chemical, a one-inch high-pressure hose with a ½-inch x 4-foot nipple permits introducing the stream of water at or near the bottom of the tank. Also, while the tank is filling, the mixture may be stirred with the nipple. The chemical mixture should be added to the mud stream at the point of maximum turbulence. If shale shakers are used, the chemicals should be introduced ahead of the shakers. This will permit them to be thoroughly mixed as the mud passes over or through the shaker.

A few short sections of walk-ways well placed are an asset to any rig.

All shale shakers should have adequate walks around them. This not only will tend to reduce accidents, but also will tend to reduce maintenance on the shale shaker. No one will wade through mud up to his ankles just to put a little grease on a bearing or tighten a loose nut or bolt unless told to do so. This is also true of the pumps. Standardizing on one type of union throughout the rig is good practice.

Circulating System

The heart of rotary drilling is the circulating system. The efficiency of rotary drilling is in direct proportion to the efficiency of the circulating system. With this fact in mind, the next logical step is the design of the most efficient circulating system.

Fortunately for the operator, equipment manufacturers have long recognized the necessity of producing durable and efficient pumps and pump parts for rotary drilling operations. The operator has only to choose the size and type of pump equipment best suited to his needs and he immediately has an almost unlimited list from which to select. Regardless of the qualities that might be built into a pump, the operator has definite responsibilities to perform, if he is to secure the maximum from the equipment that he has purchased.

The first step in securing the maximum performance from pump equip-

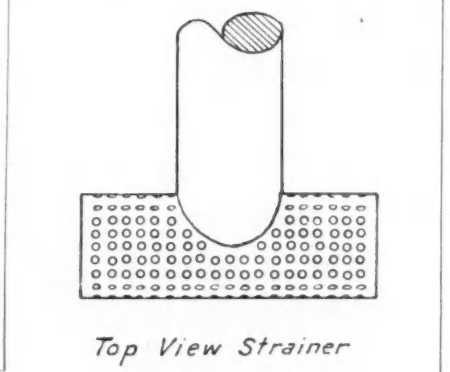
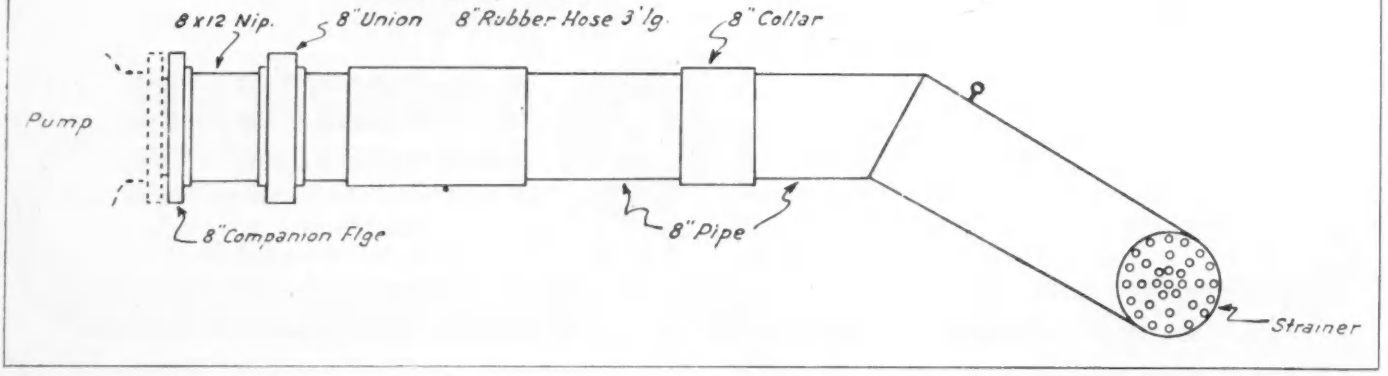


FIGURE 2. Pump suction.



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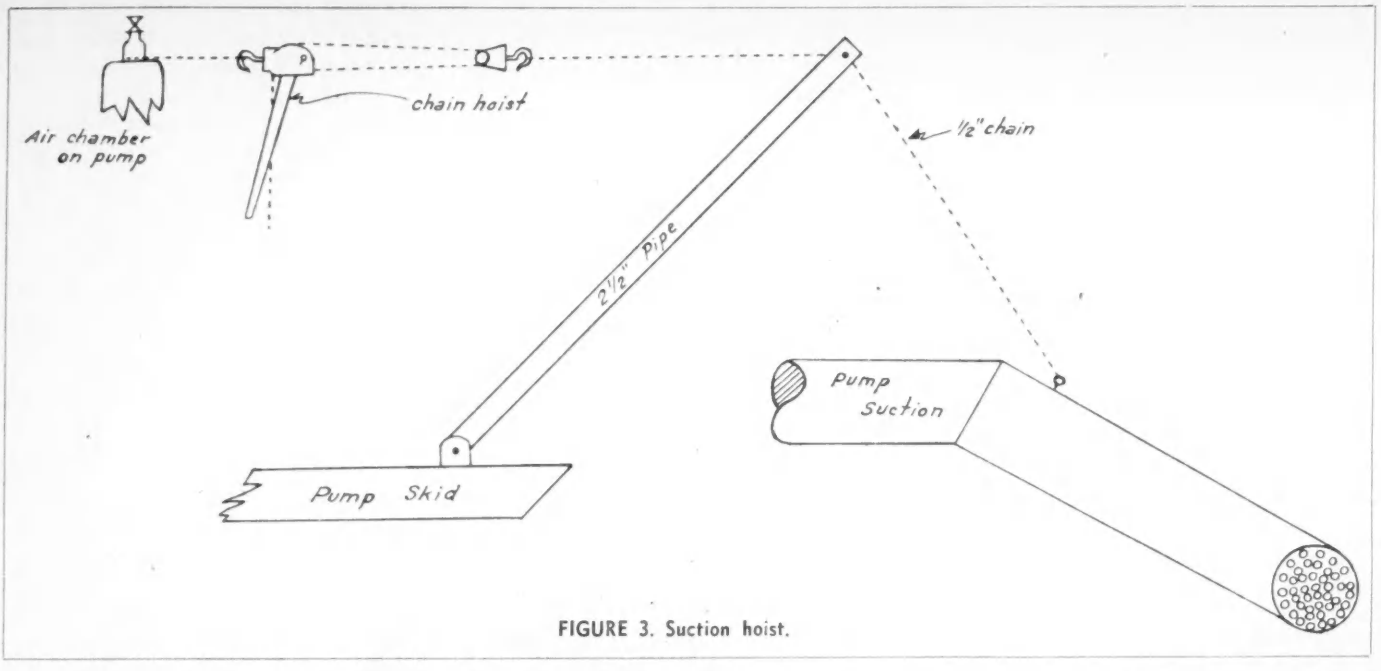


FIGURE 3. Suction hoist.

ment is the proper design of the suctions. The sucstion on any pump should be as short and straight as possible and of maximum diameter. For slush pumps, it is good practice to have a strainer on the bottom end of the suction. This will prevent trash from getting under the valves of the pump.

A suction of the following type is recommended for the larger capacity pumps. For example, the pump comes equipped with an eight-inch suction flange. Place a good gasket on the pump flange then bolt the companion flange on securely. In the companion flange place an 8x12-inch nipple, to this nipple screw an eight-inch union, either a wing or one bolt type. Next comes a section of rubber hose with short eight-inch nipples in either end. One end of the hose is screwed into the union, the other into an eight-inch collar. From the collar on the remainder of the suction is screwed (Figure 2). The eight-inch union will save considerable time in connection and disconnecting the suction. Also, when more than one pump is used and it becomes necessary to compound them, it is a very easy matter to disconnect the suction and place a blanking plug in the union. The section of rubber hose makes the suction very flexible, which facilitates raising and lowering the suction during drilling operations.

A very simple hoisting arrangement for the suction can be made from two pieces of 2½-inch pipe, approximately six feet of ½-inch chain, and a light weight "come along" jack (Figure 3).

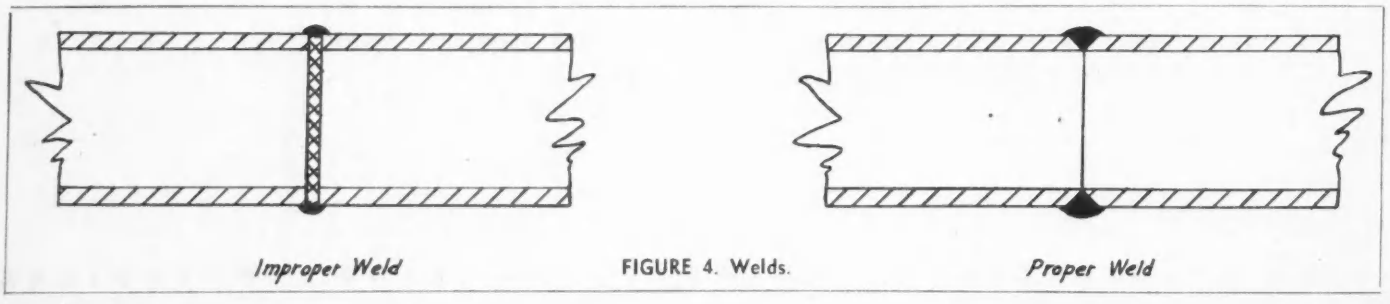
The slush pumps should be so located that the discharge lines will be as straight as possible and with as few changes in direction as conditions will permit. Each change of direction reduces the volume of delivery as well as giving one more point for leaks to develop. All drilling fluids are abrasive in action, consequently any reduction in sharp turns or shoulders will tend to reduce this abrasive action, which in turn will prevent leaks and prolong the life of the lines.

Welds in mud lines are a constant source of leaks, because the average welder butts two pieces of pipe together and runs a bead around them. This leaves a crack between the two pieces of pipe that will cause turbulence in the fluid; and because the fluid is abrasive, it starts cutting out. To combat this abrasive action, the pieces of pipe should be beveled before being welded. This beveling can be done with a torch. The beveling will permit the maximum penetration of the weld (Figure 4).

The life of the fluid rods in a slush pump can be greatly increased by circulating oil on them in the place of water. Water causes them to pit and become very rough. With the use of oil, they acquire a high polish. This high polish prevents leaks and also increases the life of the rod packing.

A very simple circulating system can be made for power pump rods by using a small centrifugal pump mounted in such a manner that a small V-belt from the drive shaft will rotate the centrifugal pump. Run a one-half-inch line from the discharge to a point directly over the rods for the oil. The suction from the pump line will be tied into a container mounted on the slush pump skid directly under the rods. As the oil leaves the rods, it will drain into this container. The oil will be changed only when it becomes contaminated with mud and water.

Frequently, this type of equipment does not receive the care it should, especially when not in use. An operator can save considerable upkeep by providing individual racks for the blow-out preventer and master valves. The racks should be constructed in such a manner that the flanges will be afforded the maximum protection at all times. The most efficient manner to accomplish this is to construct the racks so that when the preventers are placed on them they will be in the upright position. The racks should be long enough to enable loading them with a winch line, and also protect any parts of the equipment.



Improper Weld FIGURE 4. Welds. *Proper Weld*

The Built-in Features of an
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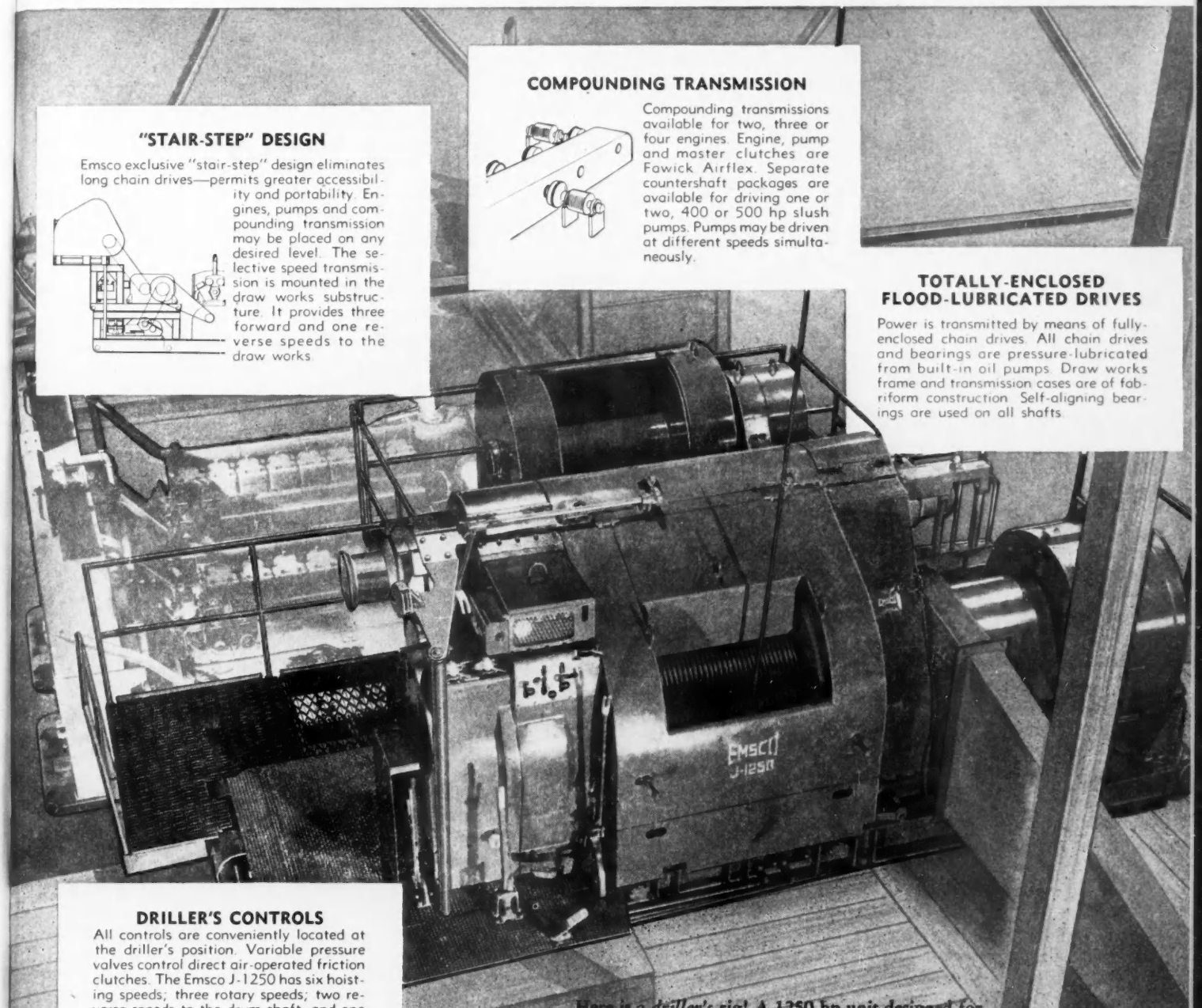

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Emsco exclusive "stair-step" design eliminates long chain drives—permits greater accessibility and portability. Engines, pumps and compounding transmission may be placed on any desired level. The selective speed transmission is mounted in the draw works substructure. It provides three forward and one reverse speeds to the draw works.

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Power is transmitted by means of fully-enclosed chain drives. All chain drives and bearings are pressure-lubricated from built-in oil pumps. Draw works frame and transmission cases are of fabriform construction. Self-aligning bearings are used on all shafts.

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All controls are conveniently located at the driller's position. Variable pressure valves control direct air-operated friction clutches. The Emsco J-1250 has six hoisting speeds; three rotary speeds; two reverse speeds to the drum shaft, and one to the rotary. The Emsco Type J Brake provides smooth, equalized action eliminating kicking, chattering or grabbing.

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Chemistry of Drilling Fluids

By H. T. KENNEDY
Gulf Research & Development Company

PROPER SELECTION and use of mud mixture or drilling fluids is one of the most important factors connected with drilling operations. Only by knowing the physical properties and the reaction of drilling muds under given conditions can a well be drilled efficiently and economically. In order to meet this requirement the field man should have a fundamental knowledge of the chemistry of mud.

THE chemistry of drilling fluids is largely the colloid chemistry of the materials that maintain the fluid in a highly dispersed state. Thus, while water or oil, together with weighting materials, make up the bulk of drilling muds, they are for the most part inert and affect mainly the physical rather than the chemical properties. Since these physical properties are well discussed by other authors, this paper will be limited to the chemistry of materials such as (1) clay, bentonite, starch, and gums, and agents such as tannates and phosphates which exert a controlling influence over them; and (2) asphalt, lamp black, soaps, and the like which perform similar functions in oil-base muds.

Although fineness of division is a prerequisite for the colloidal state and for the properties associated with good drilling fluids, fine grinding is not in itself sufficient to guarantee the desired characteristics. Thus, amorphous silica may be obtained in extreme fineness, and may be used as an effective weighting agent, but it does not impart to a drilling fluid the same filtrate reduction and stability against settling as does clay. The materials and processes which do impart the desired characteristics are quite different for water-base muds than for oil-base muds, and these two fluids will be discussed separately.

Water-Base Muds

Until recently, most rotary drilling fluids consisted of water and clay, the latter material being obtained from the formations as drilled or being added from local sources. As wells became deeper, the properties of the simple clay-water mixtures were found to be increasingly inadequate to meet the more severe requirements. Clay-water mixtures of sufficient density to control high-pressure sands were too viscous to be handled, and Stroud[1] added heavy weighting materials which increased the weight without greatly affecting the viscosity. A second step in increasing weight without sacrificing other properties was the replacing of part or all of the clay with a more powerful suspending agent, bentonite, so that more of the solid portion of the mud could consist of heavy material such as barium sulfate.[2] A third step consisted in adding agents such as tannates[3] and phosphates,[4] greatly thinning the mud and allowing still higher percentages of weighting material to be added.

In modern drilling practice, increasing emphasis is placed on the wall-building properties of muds, as measured by the filtrate obtained in the Baroid tester.[5] Clay muds, without further additions, may have filtrates (in excess of 50 cc. in 30 minutes), and may cause difficulties in drilling due to the invasion of producing formations by the separated water and mud-ringing of the hole by the deposited cake. Loss of drilling fluid and accelerated heaving of shales may also result.

The viscosity, gel strength, filtrate, and stability as regards settling are controlled to a great extent by the degree of deflocculation of the colloidal material in a drilling fluid. The degree of deflocculation, in turn, frequently is dependent on the presence or absence of very small amounts of certain materials whose action is explainable in terms of their effect on the electric charges carried by the dispersed particles. The reality of these charges has been demonstrated by placing a dispersed clay in an electric field and observing the motion of the individual particles toward the positive pole, which proves that the charges are negative. Hauser and Le Beau[6] have studied the velocity of particles of selected bentonite, and have calculated from the results an average apparent particle diameter of 20-96mμ, and an average distance between particles of 94-738mμ. The results are presented as a first approximation only.

Clays useful in drilling fluids consist principally of aluminum silicate, with small percetanges of iron, magnesium, calcium and alkali metals, oxides and variable amounts of water bound in the molecule. Hoffman[7] and coworkers have presented an idealized picture, based on x-ray diffraction patterns of the bentonite particle. According to these authors, bentonite exists as a sheet in which a plane containing largely aluminum oxide is enclosed both top and bottom by sheets containing silicon and oxygen, as shown in Figure 1. This picture has been widely accepted, and when allowance is made for substitution of other metals at various points in the lattice, it may be used to explain many facts in the chemistry of clays.

According to this concept, bentonitic clay swells because water of hydration can penetrate between the aluminum-silicon planes, with excess water existing between the particles, outside the lattice. Ford, Loomis ,and Fidiam[8] have explained in detail the action of various viscosity-reducing agents, as adsorption of negative ions of the agent on the exposed aluminum atoms on the ends of the plates and consequent rupture of the plate structure. The gelling and coagulating action of salts is explained as an

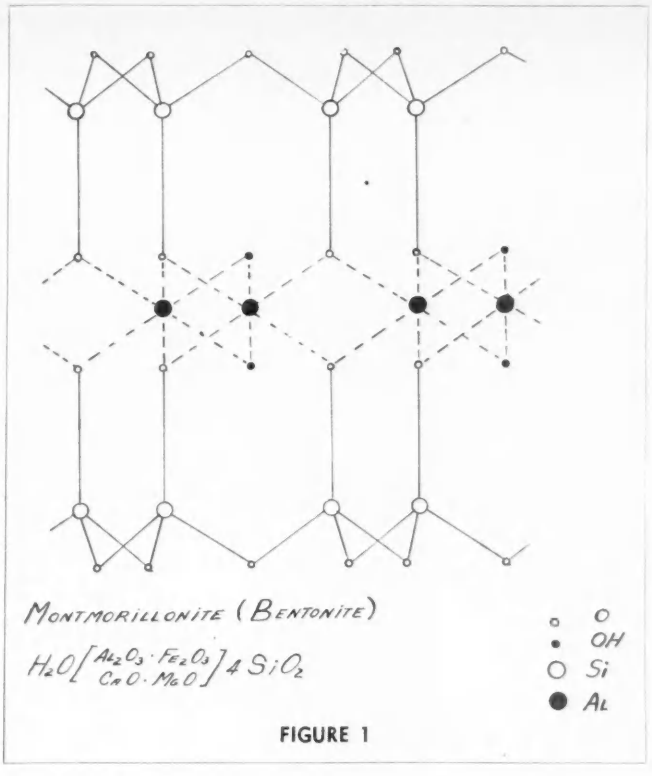


FIGURE 1

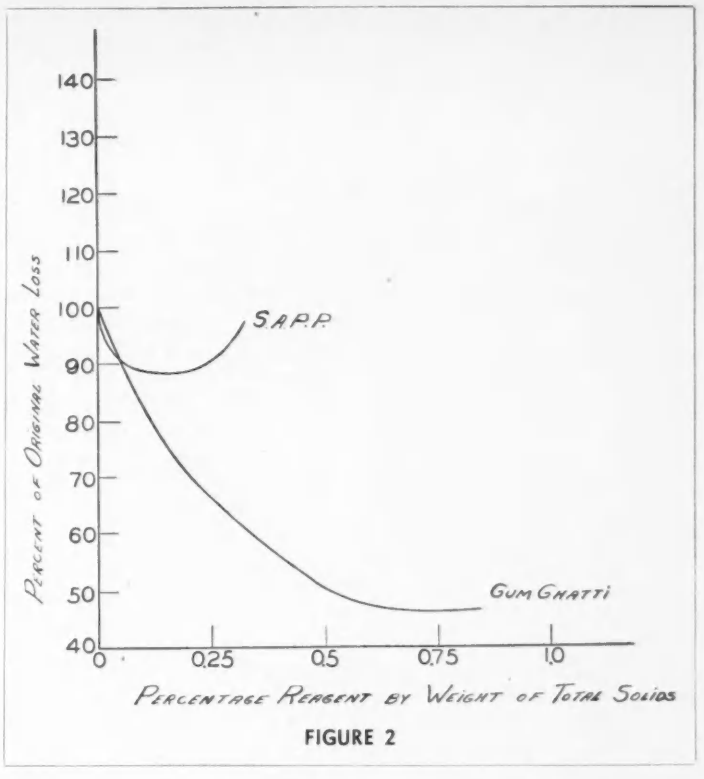


FIGURE 2

effect on the ionic atmosphere rather than on the clay particle itself.

Regardless of the detailed mechanism, certain facts of the chemistry of clay drilling fluids are well established. Small quantities (up to 0.1 percent) of salts such as sodium chloride are beneficial in dispersing the particles and providing better stability and lower filtrates, while further increase in salt concentration leads to complete flocculation and very large filtrates. Some clays resist visible flocculation, but the increase in filtrate shows that coagulation of particles is occurring nevertheless. No practical method has been found to prevent the deterioration of clay by salts such as are encountered frequently in drilling operations, and under these conditions, reliance for colloidal properties must be placed on starches or gums which are not similarly affected.

The effect of various materials on the viscosity of muds is shown in Figure 4, for which data have been assembled from various sources. The curves are illustrative only, and are not intended to evaluate the agents since the relative effectiveness varies from one drilling fluid to another. Figure 4 deals only with fresh water muds.

Figures 2 and 3 show corresponding effects on the filtrate of clay-fresh water muds of a number of materials. As in Figure 4, the curves are not intended to show the relative effectiveness of various agents.

As previously mentioned, the effect of salts encountered in drilling is practically to destroy the colloidal nature of clays, and for this reason, it is necessary to find colloidal materials not similarly affected. Salts have little effect on dispersions of starches or certain water-dispersible gums, such as arabic, tragacanth, karaya, or ghatti, and, in many respects, muds formulated with these organic materials behave better with high salt content than in the salt-free condition. Due to the growing use of starch and the prospect of greater use of gums when market conditions become normal, their chemical properties will be reviewed.

Starch is obtained from many different sources, and the products vary considerably in properties. The empirical

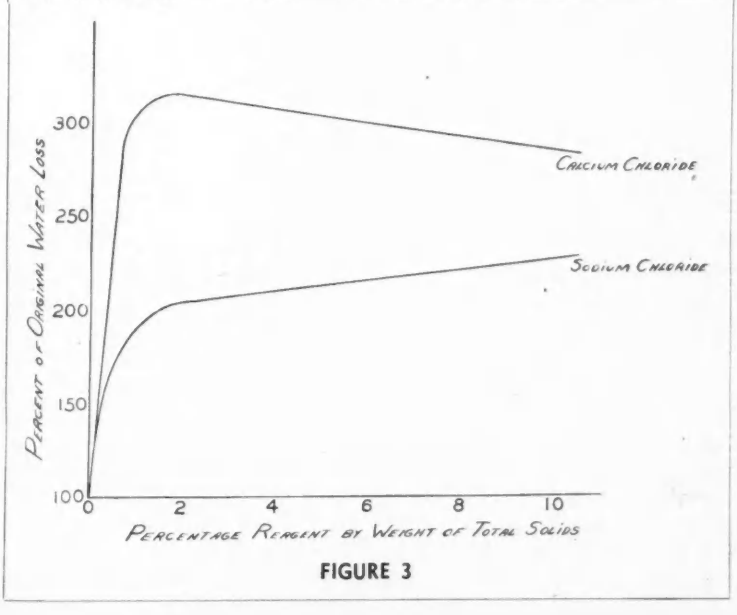


FIGURE 3

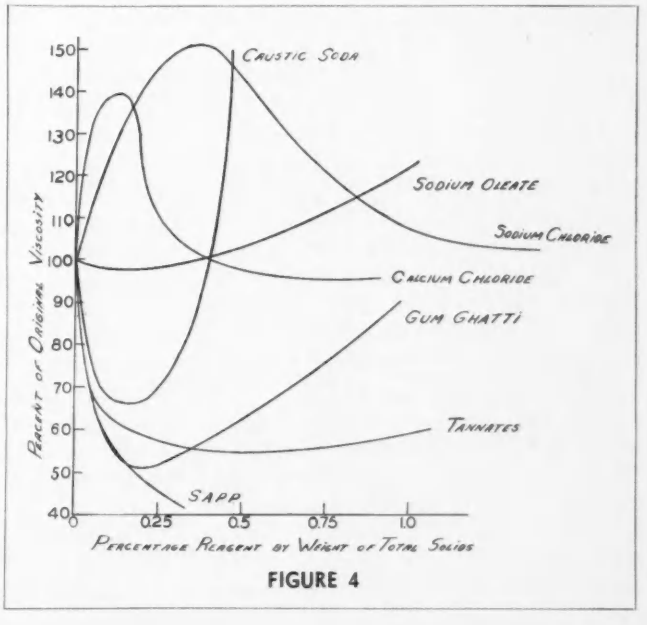


FIGURE 4

formula is $C_6H_{10}O_5$ but this formula covers widely different carbohydrates.

According to Thomas,[9] starch granules consist of two kinds, one of which is water-insoluble and known as α-amylose, the other being water soluble and called β-amylose. Starches from different sources differ in their relative proportions, as shown in the table below:

Starch	α-Amylose %	β-Amylose %
Corn	15	85
Rice	18	82
Potato	3 (?)	97
Wheat	23.5	76.5
Cassava (Tapioca)	16.5	83.5

Soluble starch, as the term is used here, refers to a dispersible material rather than one which goes into true solution. In drilling fluids it is only the dispersible variety which is of value, so that our interests are limited to β-amylose. Taylor and Iddles[10] found that soluble starches do not migrate in an electric field, indicating that swelling and not electrical stabilization is involved in starch suspensions, and accounting for the lack of effect of salts on starch-base drilling fluids.

As starch comes from the plant, is is normally in the form of cells which are covered with a tough membrane. This membrane must be removed by grinding or boiling before the starch may be dispersed. Once the skin is disrupted, starches undergo reversible swelling, in either hot or cold water, in a manner similar to bentonite.

Considerably less information is available in regard to the chemistry of gums than that of starches. Ordinarily, gums are natural mixtures of potassium, calcium, and magnesium salts of carbohydrate acidic bodies showing anodic electrophoresis, which gives them considerable dispersing and viscosity-reducing power in low concentrations (Figure 4). At higher concentrations they exhibit marked suspending power, which is not interfered with by salts such as NaCl and $CaCl_2$ encountered in drilling. Karaya gum is distinctly acid, giving off the odor of acetic acid, and is destroyed by highly alkaline solutions. Ghatti gum is more stable and contributes more to lowering the filtrate and less to suspending the solid particles. Both the latter gums are particularly valuable in the formulation of drilling fluids of high salt content.

Mention should be made of agents which assist in the release of gas bubbles by concentrating in the interface between liquid and gas, and thus cure the difficulty known as gas cutting. A number of materials are effective for this purpose, notably alcohols, acetone, and other light solvents.[11] Other compounds such as higher alcohols[12] and fatty acids[13] may be used for the same purpose.

Water has a tendency to cause shales to heave, i.e., to slough and bridge the hole during drilling and to swell clays in producing formations, resulting in a considerably reduced permeability and thus lower productivity of the pay sands. Oil is inert to most clays and shales, and its use as a base for drilling fluid is increasing even though the cost per barrel is generally considerably higher than for water-base muds of comparable properties. In place of bentonite, starch or gums as a stabilizing agent, soaps,[14] lamp black,[15] or asphaltic material[16] have been employed, with resulting filtrates of a very low order, frequently less than 1 cc. in 30 minutes.

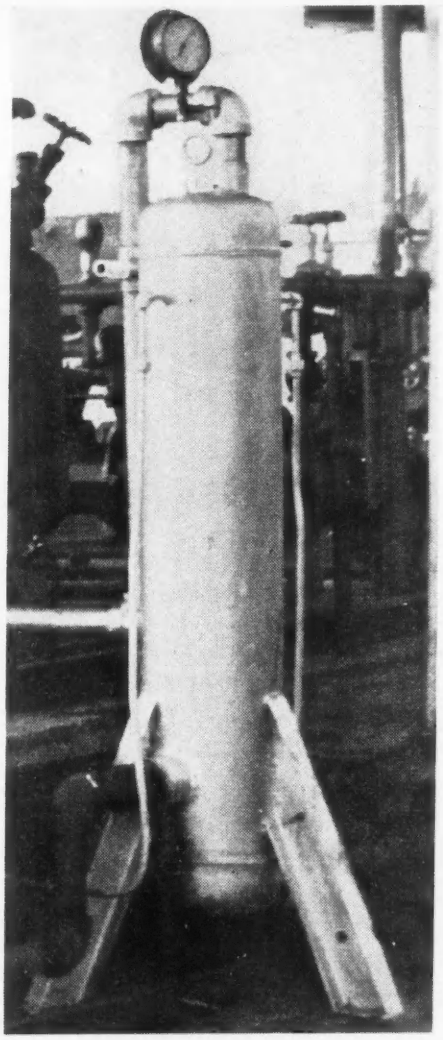
Fuel Preheater

TO PREVENT freezing of the gas line at the regulator, one fireman developed a preheater which utilizes steam instead of open flame for raising the temperature of the incoming stream of gas. The unit consists of a shell of ten-inch pipe, with dished ends, and supported on a tripod of size and rigidity sufficient to prevent overturning. Fuel enters the shell near the base, and is withdrawn through a nipple welded into the top head.

Inside the shell is suspended a coil of copper pipe, wound to fit snugly within the shell and having inlet and outlet at the same level. The coil is attached to nipples welded through the shell, and spaced so that the bottom of the coil is about six inches above the inlet line. A needle valve on the steam line provides the necessary regulation of the flow through the coil, the exhaust end of the line being left open and discharging to atmosphere.

By allowing condensate to collect within the shell up to a point where it will cover the inlet pipe, a scrubber effect is obtained by allowing the incoming gas stream to bubble through the condensate, this action trapping rust particles and other solid matter carried in the gas stream.

The unit is mounted vertically for preheating gas fuels, but may be laid on its side, with the flow reversed and flow taken through the side fitting if fuel oil is to be preheated. The flow is then such as to keep the shell completely filled at all times, avoiding the formation of a gas pocket and possible damage to the device.



Pipe collars welded to both top and bottom heads afford means of attaching a pressure gauge at one end and of draining off excess fluid at the other.

The unit is large enough to preheat the entire fuel supply for a battery of boilers, whether the fuel be oil or gas, and to prevent freezing of the regulator when gas is burned.

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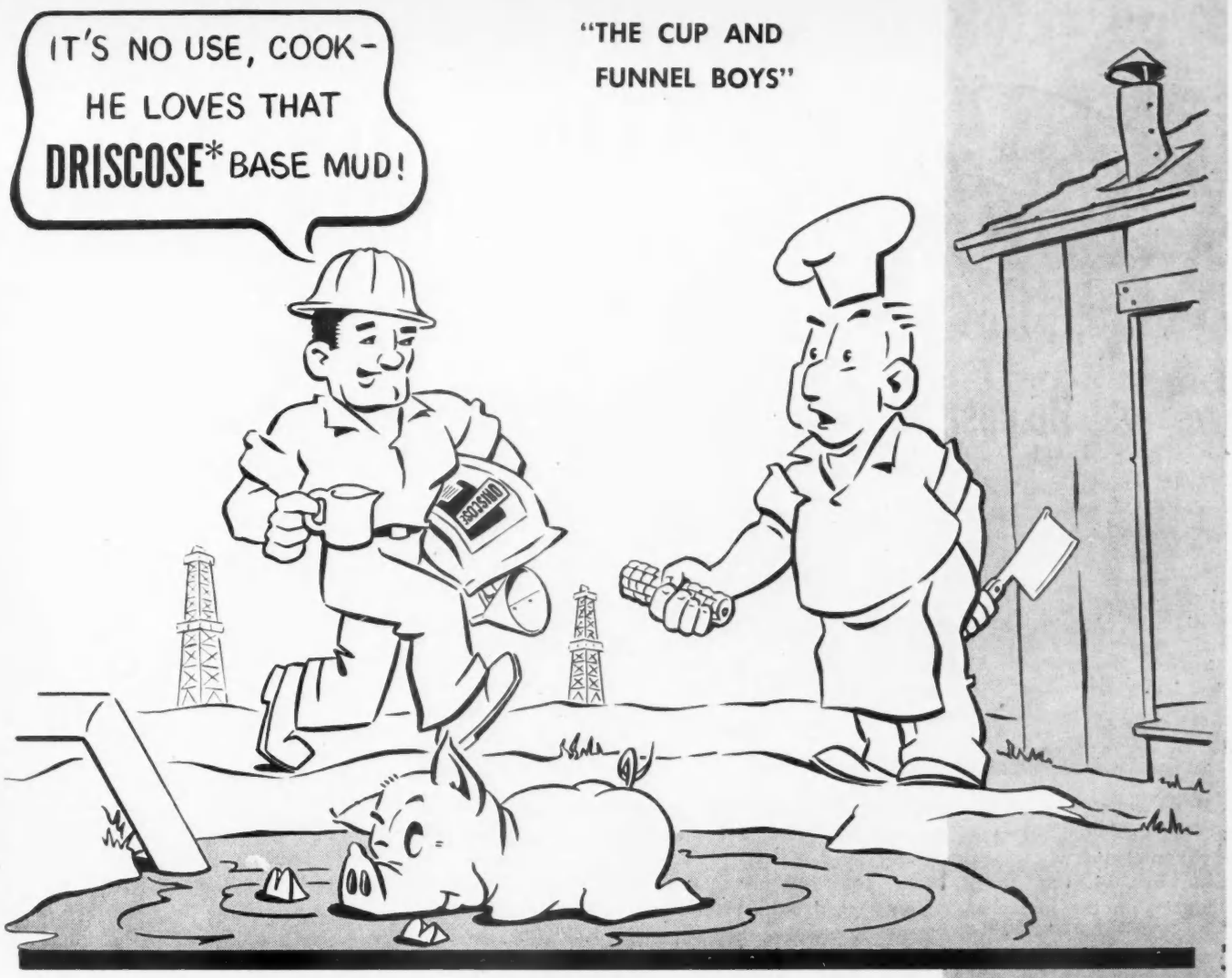

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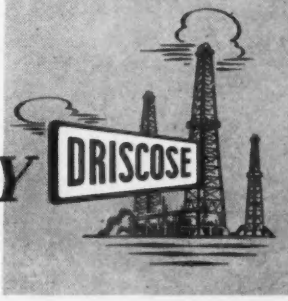

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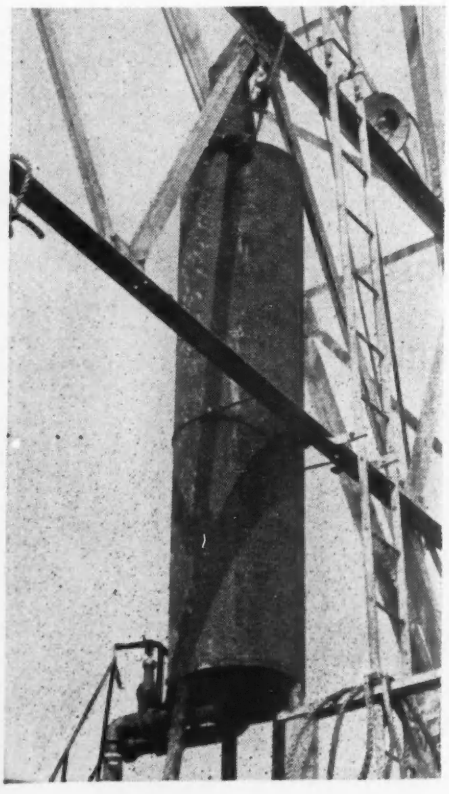
How To— Dispose of Boiler Wash Water through Drainage System

Many boilers are cleaned by removing the handhold plates at the bottom of the mud ring where no provisions are made for diverting water, scale and sludge from the immediate vicinity of the battery. To keep the premises clean, one contractor has fitted the battery of boilers at the drilling rig with receivers placed below the handhole plates so that sludge material discharged from the boilers will not collect at the battery.

Square funnels are attached to pipe which connects into a common trough so that all material removed from the boiler through the bottom handhole openings will flow, or can be washed away from the boiler setting. The funnels are set snugly against the mud ring below the handhole opening, and welded to the substructure upon which the boilers are permanently set. All four manholes of each boiler are similarly equipped so the fireman or boiler maker, can hose down the interior without creating a series of mudholes under the boilers, or in the immediate area.

How To— Simplify Casing Fill-Up with Mud Pump Over-Flow Surge Tank



When running casing into the hole, it is sometimes desirable to stop and fill it up at 500 or 1000-foot intervals. This is usually done with the standby rotary hose where dual standpipes are used, or by connecting to the base of the standpipe either a rubber or steel hose. Mud is then pumped through the line into the open end of the casing supported in the hole. The flow of mud is controlled by alternately starting and stopping the mud pumps, which, if the mud level in the casing rises too high unnoticed, a large volume of mud may be overflowed before the pumps can be shut down.

The chamber illustrated was designed to provide a means to instantly cut off the flow of mud into the casing without having to shut down the mud pumps. The device consists of a five-foot section of 12-inch casing, sealed at both ends and supported in an upright position at the edge of the derrick by a tubular tripod. Two connections are made at the bottom to provide a two-inch mud inlet from the standpipe line; the other is a similar connection to which is attached a rubber hose of sufficient length to reach to the casing for filling the latter with mud. This discharge line is equipped with a quick-opening and closing gate valve which operates by a short lever.

Top of the chamber contains a three-inch connection which is carried to the mud return ditch. With the standpipe line closed off upstream of the connection to this chamber, and by allowing the mud pumps to operate slowly, mud will be circulated through the chamber and back into the mud ditch. If it becomes desirable to fill the casing, the flexible hose can be placed in the casing and the quick-opening valve opened. When the mud reaches the desired level, the mud flow can instantly be shut off, and the flow will be diverted through the overflow line into the ditch. The pumps can continue to operate until the next fill-up stop.

Height of the chamber in the derrick determines the fluid head causing flow into the casing. This height can be adjusted to suit the operator by means of the tripod and "U" bolt clamps.

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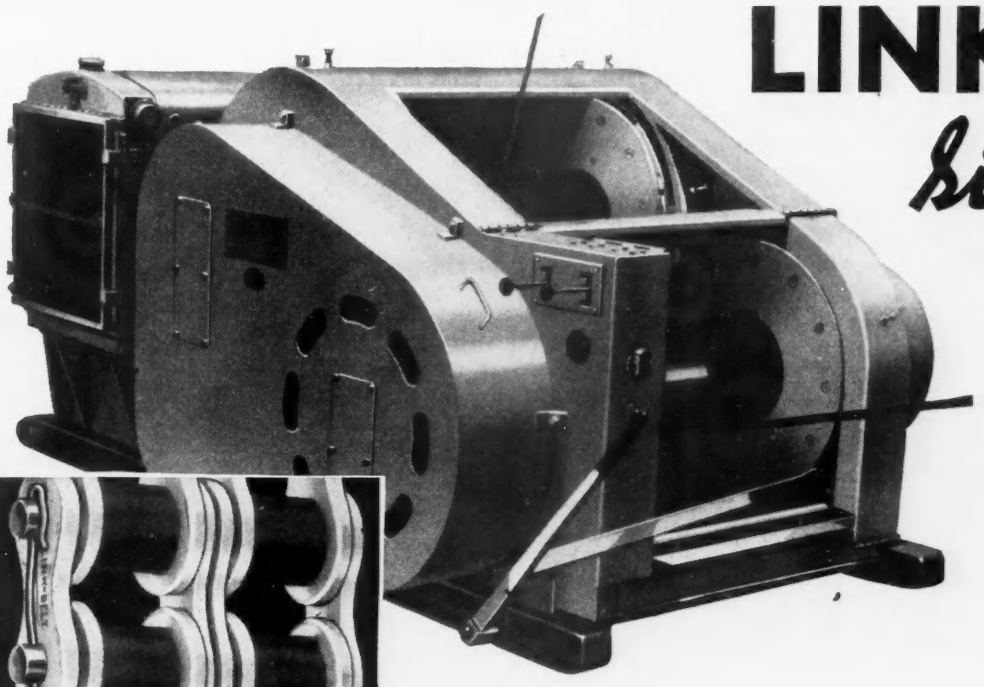

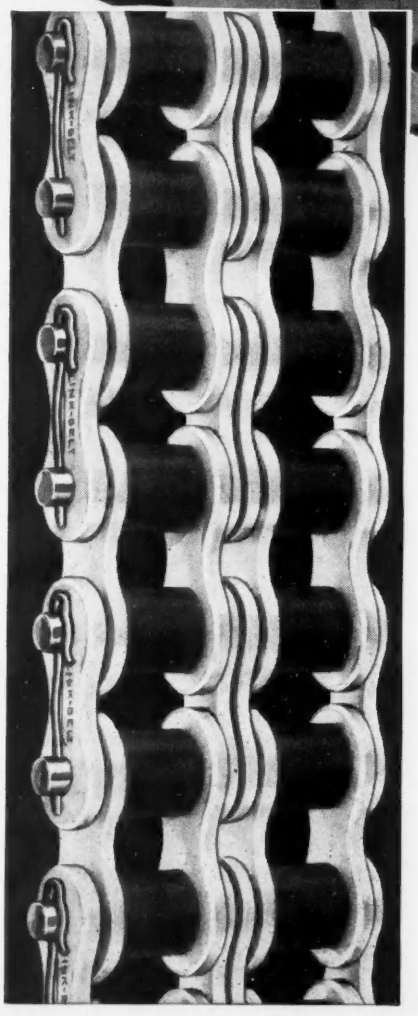

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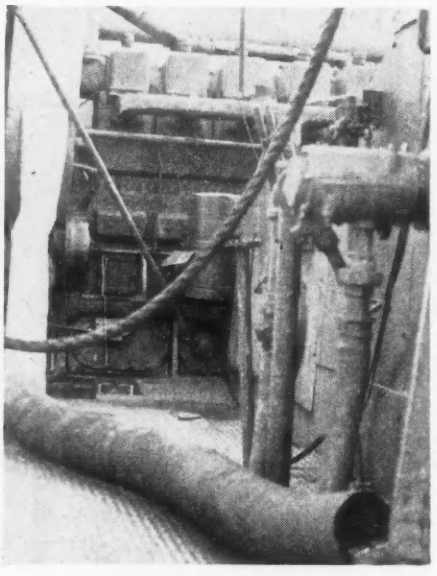
How To— Provide Heat for Driller on Power Rig

One advantage the steam rig has over the power rig is the availability of heat to keep the crew warm during the cold winter days of drilling. Between round trips the crew can retreat to warmer areas, but the driller on power rigs must remain on the derrick floor beside the cold drawworks and keep himself warm as best he can.

Equipment layout on one particular power rig made it possible to provide heat to the man on the brake. This ingenious method takes advantage of the heat dissipated in the cooling system of the internal combustion engines located immediately behind the drawworks.

A cowling of sheet metal was made up so it closely fit around the radiator cooling fan on the engine. The cowling was mounted on the radiator by iron brackets as shown. An exhaust was provided from the cowling so that air drawn through the radiator could be exhausted through a duct placed on the floor along side the drawworks. The last ten feet of this duct was of eight-inch flexible rubber hose so that it could easily be rolled out of the way when it became necessary to use the cathead or to work on the power transmission.



During drilling operations, cold air is drawn through the cooling radiator where it is heated and then forced through the duct connected to the cowling. Hot air is blown up from the floor around the driller's position at the brake, and thereby providing the driller with ample heat to keep him warm on cold wintery days.

How To— Build Drill Pipe Wire Line Adapter

A time-saving and unusually efficient device designed and built up by the drilling department of one company consists of a light sheave or pulley welded to the lip of a cut-away portion of the pin end of a piece of salvaged drill pipe. Shown in the photograph, the tool was designed for speeding up the running of the wire line in such operations as running directional surveys.

Instead of rigging up lines and pulleys above the well, with the attendant time-consuming work of centering and steadying the pulley over the center of the hole, this device is merely screwed into the open box end of the drill pipe string hung in the hole, and the instrument run in over the permanently positioned pulley. When the survey is completed, the adapter sub is as easily removed and stored with other tools at the edge of the derrick floor. The minutes saved on each run quickly add up to hours, and at today's high operating costs, soon amount to an appreciable saving in the total cost of the well.

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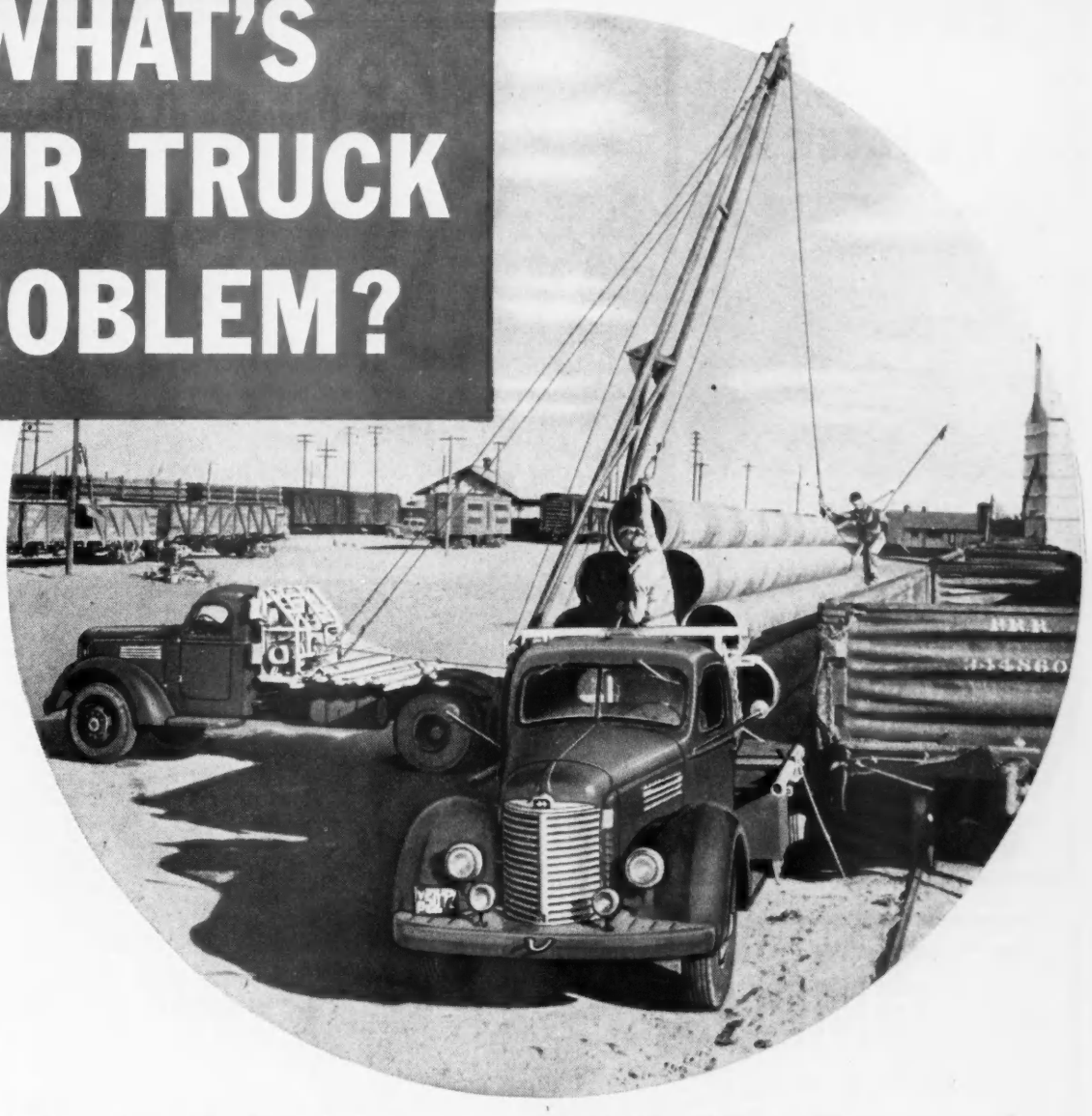

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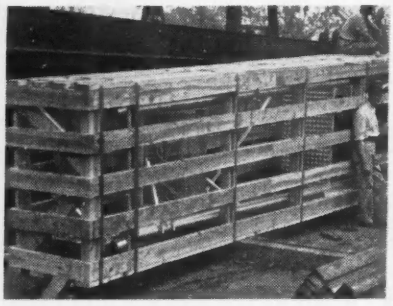

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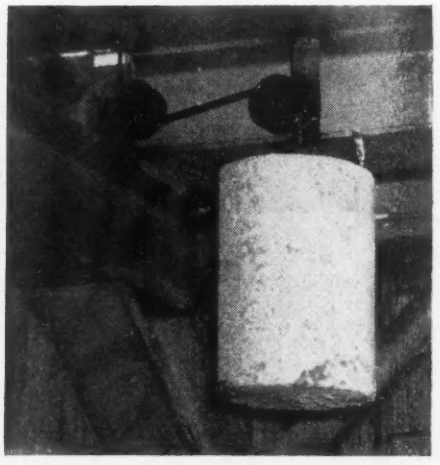
How To— Change Direction of Counterweight Line

Heavy pipe tongs are counterbalanced with a weighting device which is normally located in one corner of the substructure below the derrick floor so the small cables attached to the tongs and counterweight are out of the way for drilling lines, etc. In one particular power rig where the substructures had been unitized, it was impossible to locate the counterweight beneath the floor so the return line would travel in one corner of the derrick.

To combat this situation, the rig designer diverted the direction of pull by means of two pulleys, thereby placing the line in the derrick corner and permitting the counterweight to fall freely inside the clear space under the floor. Two metal pulleys of four inches in diameter were welded to the substructure. One pulley was located so that the small cable would travel in the derrick corner, and the second was welded to the cross-supporting I-beam to permit the large counterweight to fall unobstructed. The cable was threaded through the pulleys as shown and the concrete-filled casing was attached. Some friction was introduced, but not enough to adversely affect the operation of the pipe tongs. This system could be used on any rig where the same problems are encountered.



How To— Remove Accumulations From Rig Cellar

The accumulation of water, oil and drilling fluid is inevitable in cellars excavated below the derrick floor to accommodate the well head equipment during drilling operations. With this accumulation, it is difficult for any crew member to make adjustments or repairs on equipment located in the cellar.

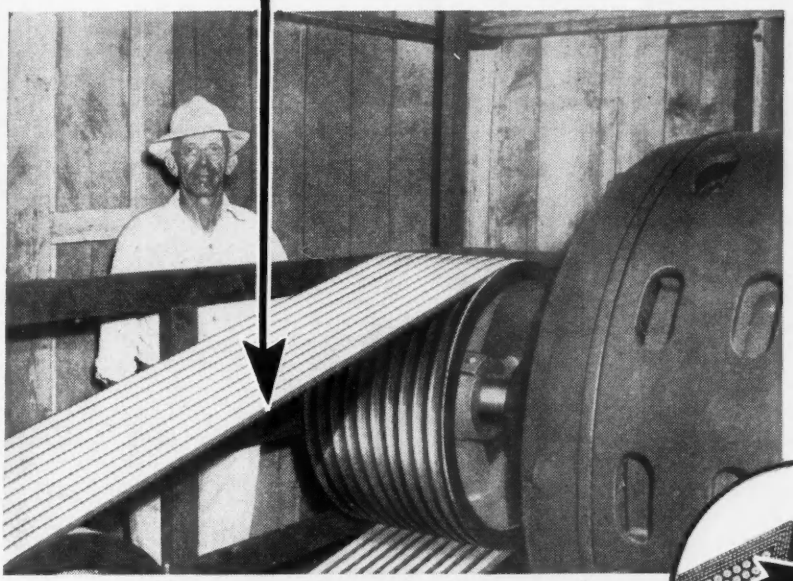
A relatively simple device which can be fabricated by a welder and which will easily remove any liquids in the cellar when desired is the water jet lift which is illustrated. The jet is created by water under pressure conducted by 1¼-inch pipe shown at left. Intake of the device is quite close to bottom of the cellar and when fluids accumulate they flood the jet. When water is jetted through the nozzle at high pressure, it entrains the fluids and removes them from the cellar.

The discharge and body of the device is a section of seven-inch casing welded in the shape of an ell, one leg of which rests on the surface next to the cellar, while the vertical member extends into the shallow pit. The 1¼-inch water-conductor line is welded concentrically inside the vertical seven-inch casing. At the intake of the casing, the stream of water is diverted 180 degrees and is jetted back to the surface. The discharge end of the device can be diverted onto the ground or into the shale pit. It is sturdy to withstand rough treatment in moving, and involves little expense.

The SIDES of a V-Belt . . .

Diagram of V-Belt in Sheave Groove

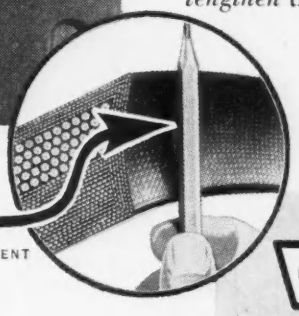
Really DRIVE the Pulley
They PICK UP and DELIVER the POWER!
Naturally They GET the WEAR



Anyone experienced with V-Belt drives knows that the *sides* of a V-Belt are what really get the wear.

It's the *sides* that grip the pulley. They pick up all the power from the driver pulley, transmit that power to the belt as a whole and then, once more, deliver the power to the driven pulley. Moreover, it's the sides that take all the wear against the sheave-groove wall.

That is why you have always noticed that the *sidewall* of a V-Belt is the part that *wears out first*—and, naturally, if you prolong the life of the sidewall, you *lengthen* the *life* of the *belt!*



Now see How the Patented Concave Side

A GATES PATENT

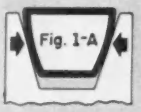
SAVES Sidewall Wear ...Lengthens Belt Life

The simple diagrams on the right show exactly why the ordinary, straight-sided V-Belt gets excessive wear along the *middle* of the sides. The diagrams show also why the Patented Concave Side greatly *lengthens the life* of the *sidewalls* of Gates Vulco Ropes. That is the simple reason why your Gates Vulco Ropes are giving you so much longer service than any straight-sided V-Belt can possibly give.

Saving SIDEWALL WEAR is more important NOW than ever before.

Now that Gates *SPECIALIZED* Research has resulted in Super Vulco Ropes capable of carrying much heavier loads—fully 40% higher horsepower ratings—the sidewall of the belt is called upon to do even more work in transmitting these heavier loads to the pulley. Naturally, with heavier loading on the sidewall, the life-prolonging Concave Side is more important now than ever before!

Straight Sided V-Belt



How Straight Sided V-Belt Bulges When Bending Around Its Pulley

You can actually feel the bulging of a straight-sided V-Belt by holding the sides between your finger and thumb and then bending the belt. Naturally, this bulging produces excessive wear along the middle of the sidewall as indicated by arrows.

Gates V-Belt with Patented Concave Sidewall

Showing How Concave Side of Gates V-Belt Straightens to Make Perfect Fit in Sheave Groove When Belt Is Bending Over Pulley.

No bulging against the sides of the sheave groove means that sidewall wear is evenly distributed over the full width of the sidewall—and that means much longer life for the belt!

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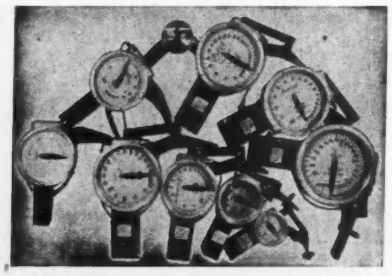

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The Trading Post
PAGE 304

DRILLING HINTS

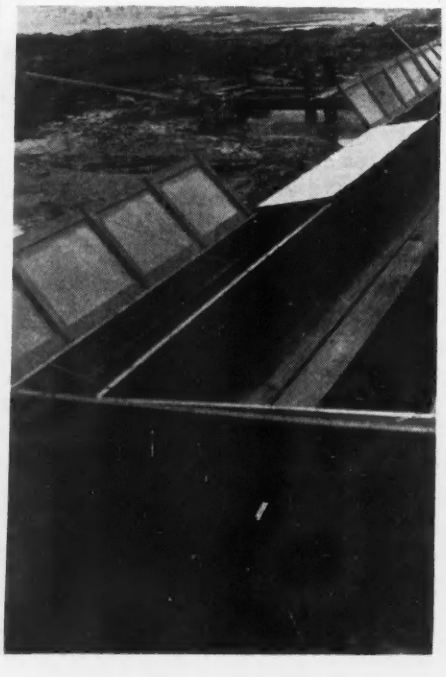
How To—

Cover Open Mud Ditches

It is sometimes desirable to cover the entire mud system to eliminate contamination by rain water and to prevent excessive drying of the drilling mud while in the ditch. Many ideas have been encorporated in accomplishing this end, from simply covering the ditch with sheets of corrugated metal to totally enclosed conductor pipe.

Where the ditches are made from lumber and elevated above the ground level, it is a simple matter to provide sectional covers or lids to keep out the rain. In the case illustrated, where the ditch is narrow and deep, the covers are made from galvanized sheet metal nailed to wooden frames designed to span the ditch. The frames are approximately eight feet long and 14 inches wide. By using four strap hinges, these covers can be attached to the wooden ditch. Three pieces of small rope or strands from a discarded catline are used to support each lid in the open position to prevent them from dropping all the way over on the side of the ditch.

It is an easy matter for the derrick man, who normally has the responsibility of keeping the mud in condition, to close the lids or open them as the need arises. When closed, these lids exclude practically all the rain from the mud system.



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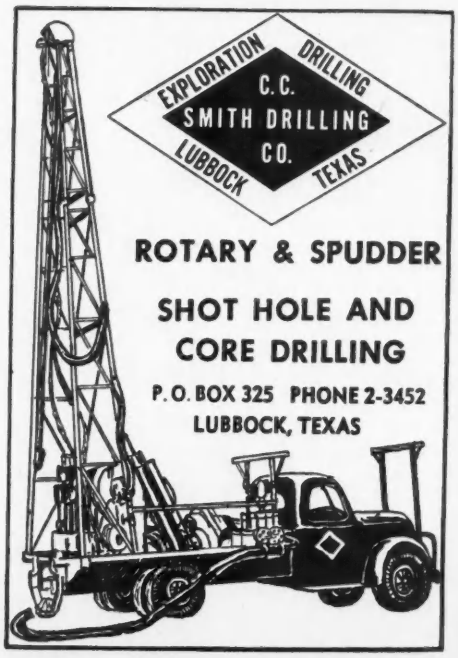

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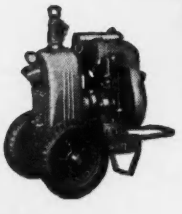

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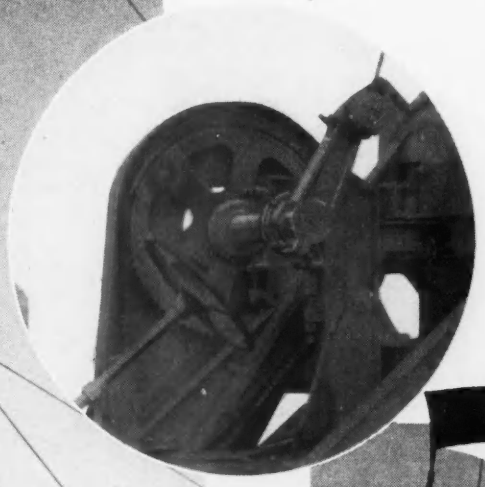
Eliminates Shock---Speeds Operations---Saves Repairs

Mobilhoist with 55-foot double leg mast "drilling-in" a rotary drilled well with cable tools.

CABLE TOOL DRILLING

Spudding assembly for all cable tool operations.



Here's the rig that has everything! Self-propelled with top road speed of 35 m.p.h. Heavy-duty special Timken-built rear axle and spiral bevel gear drive. Drums have five even-step speeds and one reverse. Rotary and spudding assemblies are interchangeable in the field. Mast is carried on mobilhoist with lines and block reeved. Recommended for servicing to 4,000 feet; 2,000-foot drilling with 3½" drill pipe, or cable tools to 3,800 feet.

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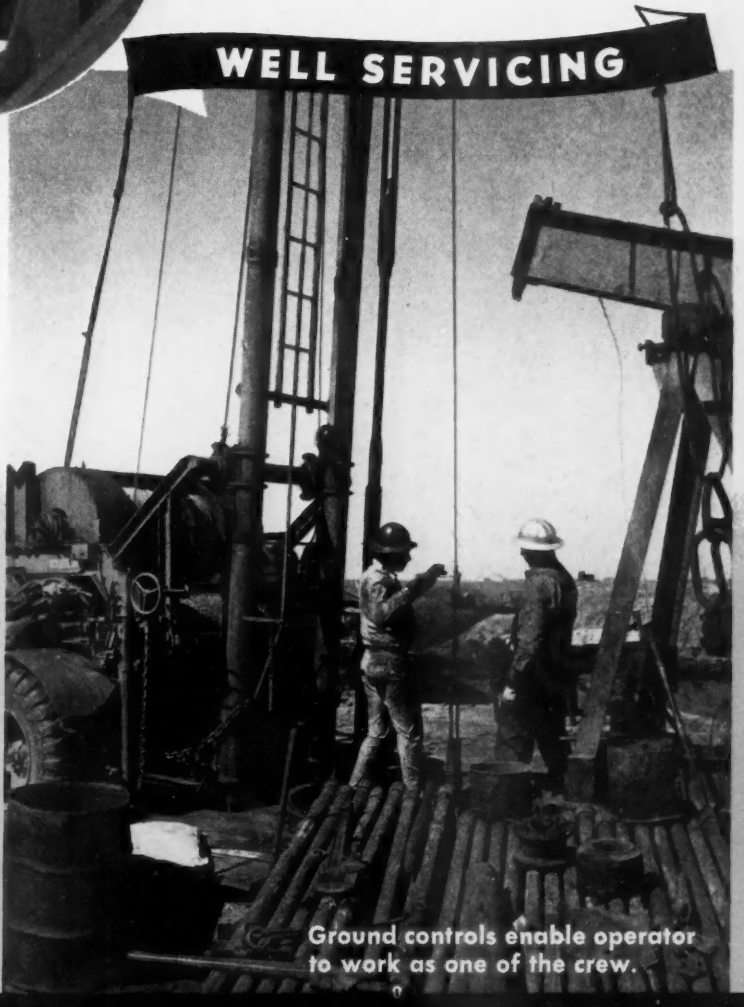

Ground controls enable operator to work as one of the crew.

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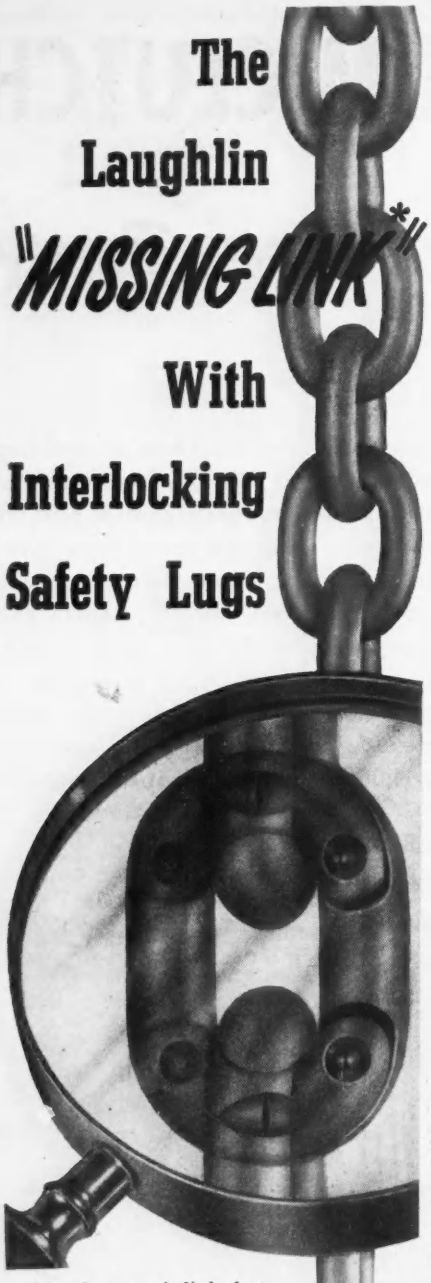

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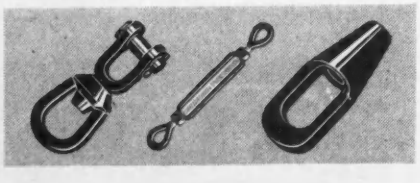

DRILLING HINTS

How To— Build Shale Shaker Chute

Where mud ditches and pits have been cut into the ground and one of these is located below the shale shakers to return clean mud back to the sump pit, it is necessary that the cuttings separated at the shale shaker not contaminate the fluid in the pit. Such a situation existed at the location shown, and it became necessary to construct a chute to conduct the cuttings over the mud pit below the shale shakers and into the shale pit.

The chute is made from sheet metal, channel and angle iron. The edges are of channel iron to add strength to the chute, while the bottom is of 1/8-inch sheet metal. It is formed into a shape similar to that of a bottle as illustrated, being necked down at the discharge. Throat or receiving end of the chute is just wide enough to span the shale shaker to which it is bolted. The device is braced across its bottom with small angle iron which is also welded to the sides to provide rigidity.

A one-inch water pipe which has been perforated is located at the shale shaker discharge so that a stream of water can be played on the cuttings as they come off the shaker screens. The water prevents them from piling up on the chute. By necking the chute down at its discharging end, the cuttings are concentrated, facilitating the task of collecting formation samples periodically. During rig moves, these chutes are stacked like trays and carried with the accessory equipment.

On an Oil Field Trailer . . .

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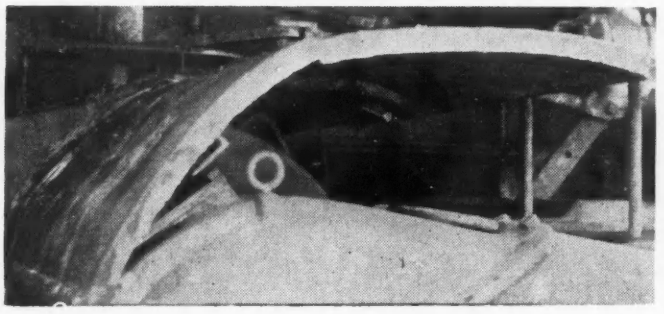
How To—

Provide Protection for Under-Floor Engines

Engines operating under the derrick floor to drive the rotary table are exposed to mud, oil and water which pours downward between the timbers. To prevent fluid and debris from being deposited and collecting on the



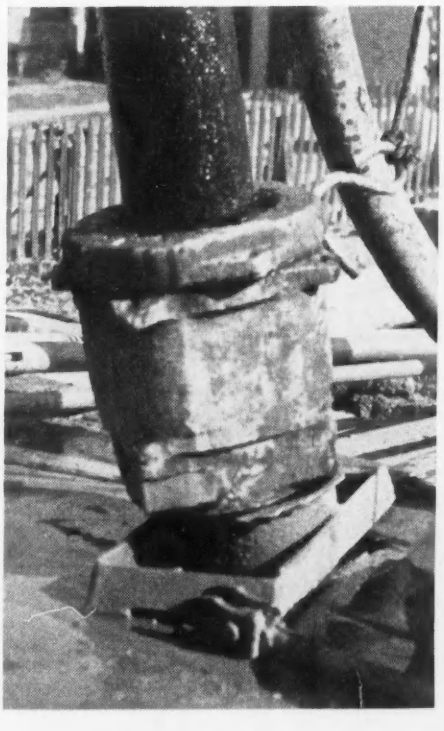
crank case and inspection plates, one company places a steel cover over the equipment.

Light sheet metal is welded to an angle iron frame, oval shaped to shed water, and the assembly set over the engine. Legs attached to one end support the cover above the engine at the front, and lugs rest on the cap screws which hold the crank inspection plate in position. During rig moves, this protection plate may be left in place, or can be easily removed if it is necessary to check the engine.

How To—

Support Rathole Casing

Ratholes are usually encased with a section of pipe to prevent the earth from caving in on the kelly and filling up the



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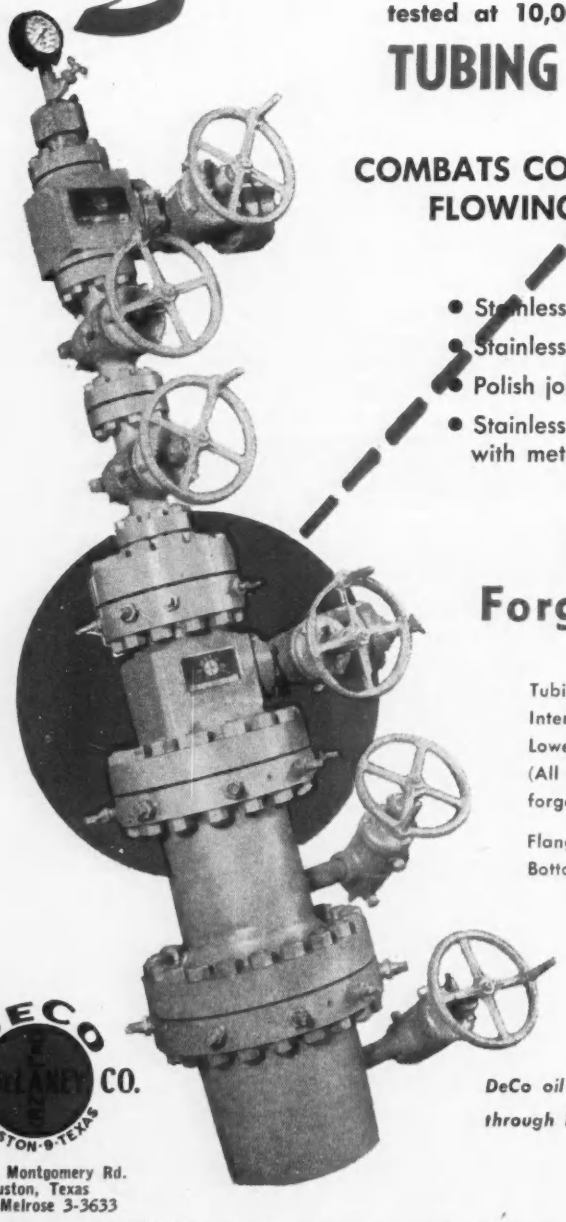

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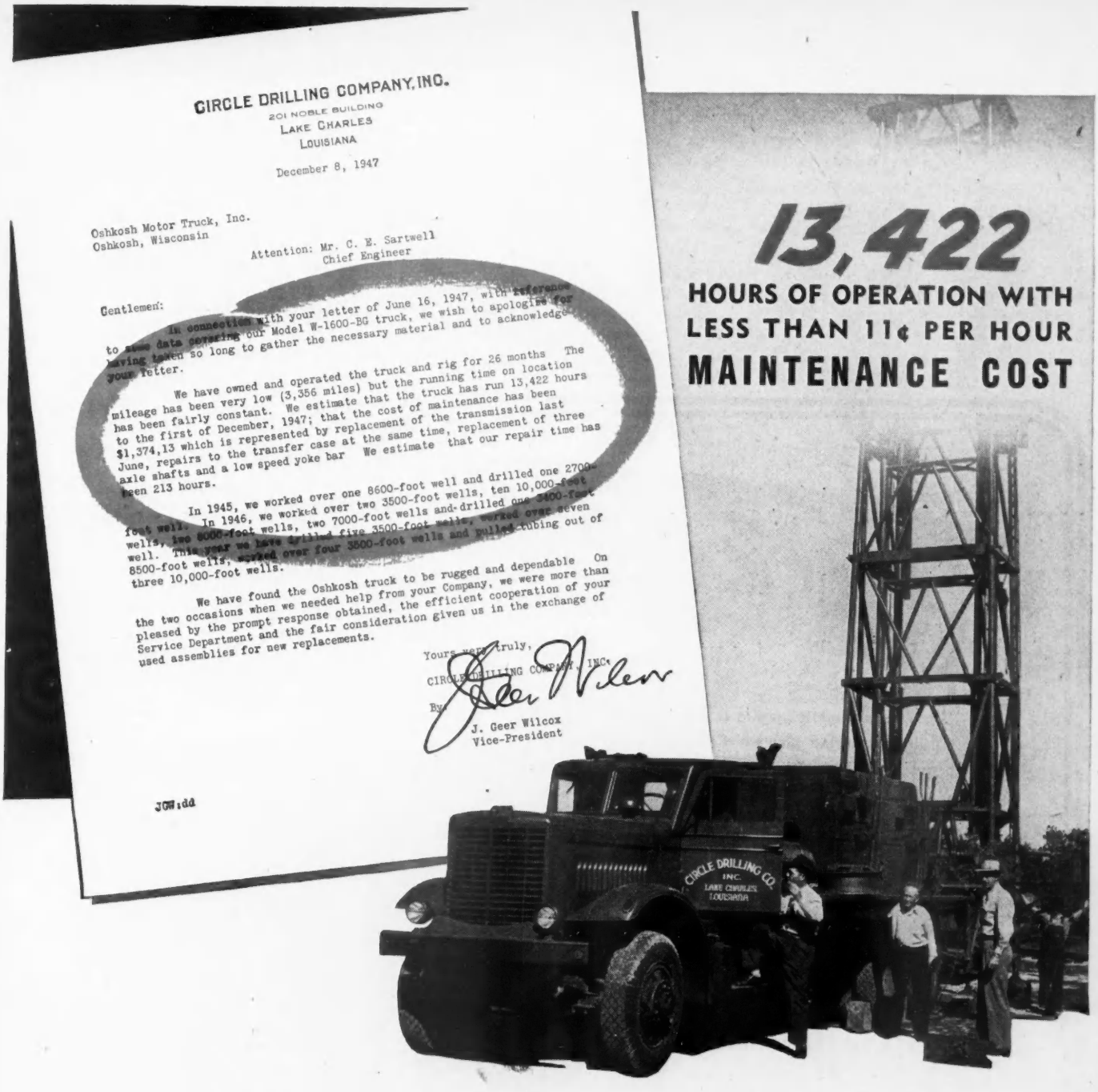
CIRCLE DRILLING COMPANY, INC.
201 NOBLE BUILDING
LAKE CHARLES
LOUISIANA
December 8, 1947
Oshkosh Motor Truck, Inc.
Oshkosh, Wisconsin
Attention: Mr. C. E. Sartwell
Chief Engineer
Gentlemen:
In connection with your letter of June 16, 1947, with reference to some data covering our Model W-1600-BG truck, we wish to apologize for having taken so long to gather the necessary material and to acknowledge your letter.
We have owned and operated the truck and rig for 26 months The mileage has been very low (3,356 miles) but the running time on location has been fairly constant. We estimate that the truck has run 13,422 hours to the first of December, 1947; that the cost of maintenance has been $1,374,13 which is represented by replacement of the transmission last June, repairs to the transfer case at the same time, replacement of three axle shafts and a low speed yoke bar We estimate that our repair time has been 213 hours.
In 1945, we worked over one 8600-foot well and drilled one 2700-foot well. In 1946, we worked over two 3500-foot wells, ten 10,000-foot wells, two 8000-foot wells, two 7000-foot wells and drilled one 3400-foot well. This year we have drilled five 3500-foot wells, worked over seven 8500-foot wells, worked over four 3500-foot wells and pulled tubing out of three 10,000-foot wells.
We have found the Oshkosh truck to be rugged and dependable On the two occasions when we needed help from your Company, we were more than pleased by the prompt response obtained, the efficient cooperation of your Service Department and the fair consideration given us in the exchange of used assemblies for new replacements.
Yours very truly,
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Oshkosh is indebted to the Circle Drilling Company of Lake Charles, Louisiana, and Mr. J. Geer Wilcox, Vice-President for the very fine letter, telling of their success with an Oshkosh Truck in Drilling and servicing operations in the last 26 months. Our files contain many such letters from operators of Oshkosh Gas and Diesel Trucks. We will be glad to show you how Oshkosh Trucks can save you money, too! A telephone call, telegram or letter will bring a quick response.

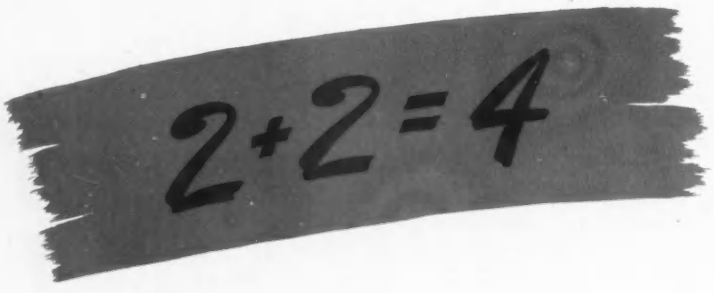
See our Exhibit at the International Petroleum Exposition, May 15-22, 1948

OSHKOSH MOTOR TRUCK, INC.
OSHKOSH, WISCONSIN
CABLE ADDRESS: "OSHMOTOR" OSHKOSH

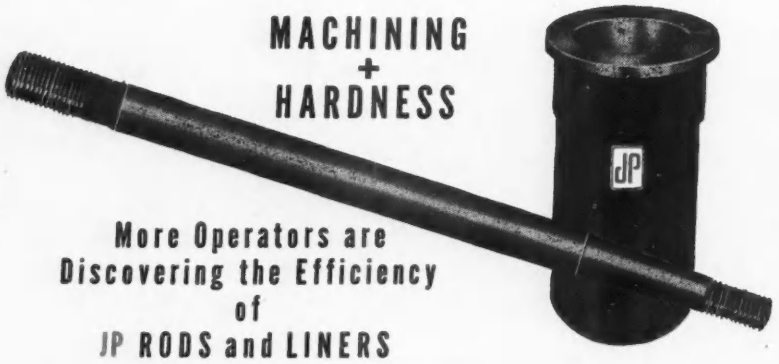
hole again. In cases where this pipe is bottomed in relatively soft formations, it is necessary to provide some means of anchoring the casing to prevent the weight of the swivel from pushing it on into the ground.

A bridge across the rathole to support the entire weight of the kelly, swivel and drive bushing solved this problem in addition to placing the swivel as close to the floor as possible for repairs and lubrication. The bridge or support was made from two short pieces of heavy channel iron which were joined at both ends by additional pieces of steel to form a rectangular base.

A six-inch collar cut from a piece of seven-inch diameter casing was set in the center of this frame and welded solidly in place as shown. The rathole casing, of the next smaller size, and in this case, 6⅝-inch diameter, was heated and belled out on the open end so that when the casing was lowered through the bridge, this lip supported the casing. The casing was several feet longer than the kelly so that all the weight of the swivel, kelly and bushing was supported by the bridge and not by the bottom of the casing. This bridge spanned the floor sills and was of sufficient strength to support the weight placed upon it. It also is a handy device when it becomes necessary to tear down the rig. By attaching a sling to either side of the bridge and placing the sling in the hook, the rathole casing may be pulled from the ground.



Simple arithmetic applies to rods and liners too. Excellent materials plus excellent workmanship, testing and hardening methods pay off with excellent results!



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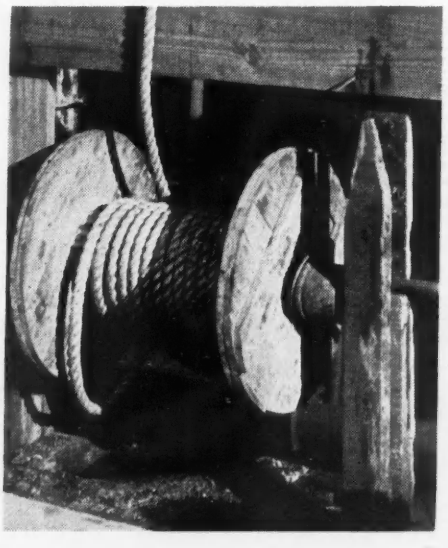
The rope is first neatly wrapped onto a discarded wire line spool (in some cases the rope is purchased in large quantities and is delivered already spooled), and supported off the ground just under the edge of the derrick floor by four upright two by fours. These may be driven in the ground or nailed to a wooden base. A short section of pipe is placed through the spool and placed between the supports. The free end of the line is fed up to the floor where one or two rounds are made around the railing. In this position it is possible to cut any desired length of line needed. It is also readily available for odd jobs on the rig floor.



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How To—

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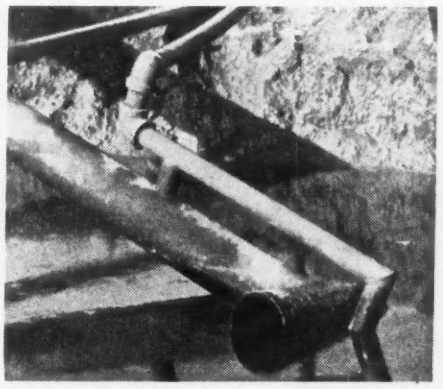
In order to permit the mud to flow freely into the transfer pipe used to jet the fluid, one drilling contractor designed an effective jet employing a tee head. The transfer line was of four-inch pipe, to the end of which was welded a one-foot tee as shown. A hole was cut in the center of the tee so that a two-inch line could be inserted in a coaxial position with respect to the transfer line. The small line was swaged down to one-inch which formed the jet. Two right-angle bends were made in the two-inch line, bringing it back across the top of the larger transfer line.



Additional fittings were added so that a short section of hydraulic rubber hose could be connected to the jet device. This pressure line was then tied into the mud pumps. High pressure steam or air could be used to serve as the lifting medium.

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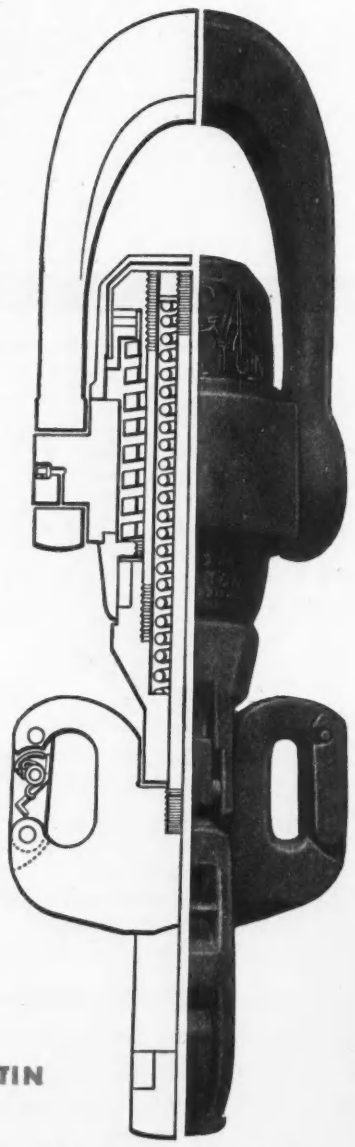

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Length of Regan Casing Hook	200-ton	300-ton
Overall length	85"	101"
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Length Working to Elevator Yoke	56¾"	60"
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Spring travel, Elevator Yoke	7½"	9½"

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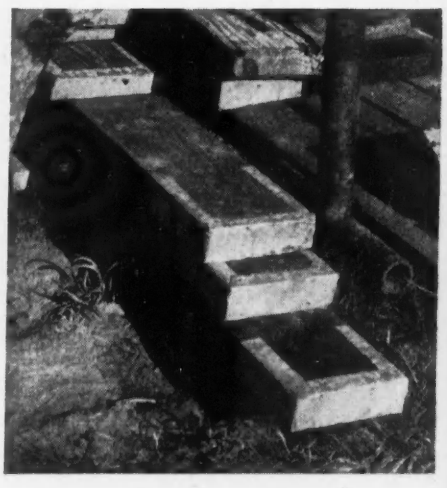
To prevent splintering and general deterioration of the wood on ends of stabbing platform planks, one company operating in the Gulf Coast region takes the precaution of sheathing the plank ends with light galvanized sheet metal. As shown in the photograph, the covering extends a foot or less down each side, and overlaps only an inch or two on to the flat sides. However, the exposed end grain and sharp corners are well protected, the metal being carefully folded at the corners and nailed at frequent intervals along all edges.



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OUTLINING the problems which must be solved for successful prosecution of a drilling campaign on the Continental shelf, the authors suggest means whereby much grief may be avoided through adequate pre-program investigations.

By CHARLES C. BATES and
ALFRED H. GLENN

Oceanography

In the Offshore Drilling Campaign

The problems of offshore drilling are complicated by many oceanographic factors, the most spectacular of which is wave action. The magnitude of extreme wave action is well illustrated by this 114-foot lighthouse in outer Boston harbor almost topped by spray during a November storm.
Photo by Press Association, Inc.

IN SOLVING the problems of drilling offshore on the Continental Shelf, the engineers of the petroleum industry are placed in a situation which by now is old and familiar . . . that of extracting petroleum under new environmental conditions. The history of petroleum engineering is one of constant progress in devising equipment and drilling methods capable of developing oil reserves at increasingly less accessible locations. Drilling has gone from shallow to deep wells, from dry land to marsh country, bayous, and shallow bays, from vertical wells to wells whipstocked under tidelands.

Now exploration departments are "staking out" locations on the ocean floor and another new environment must be conquered. The engineer's approach to a new problem is first to assemble all pertinent know-how. As a result, there has been a constant addition of specialized scientific and engineering talent to oil company staffs, and the roster of scientific talent employed by or associated with the oil industry has become a veritable anthology of the technical professions. As a result of the necessity for evaluating the effect of the oceanic environment on Continental Shelf operations, one of the latest additions to the list of sciences utilized in the petroleum industry is oceanography.

Oceanography, the science of the seas, includes such fields of study as waves, tides, currents, sea water chemistry, marine biology, submarine geology, and hydrographic mapping. The recent interest shown in these fields by various oil companies makes it appropriate to discuss the utility of oceanography in solving problems which arise in connection with drilling on the Continental Shelf.

Wave Action

One of the immediate problems which arises in any type of drilling operation conducted at sea is that of providing a stable working surface. Unlike dry land which yields only slowly or infrequently to deformative forces, the sea surface is in a constant state of agitation as a result of variations in wind, gravitational forces, atmospheric pressure, and seismic disturbances (Figure 1).

Obviously, many design and planning problems will arise because of wave action resulting from winds. In the case of drilling platforms supported by piling, there are such possibilities to be considered as swamping by wind waves or storm tides; failure of piling through wave action; scour or deposition around the piling on the ocean floor; and destructive vibration of the structure induced by waves. Design engineers must, for example, know the maximum wave heights to be expected, the frequency of occurrence of various periods and height ranges of the wave spectrum, and the fluid velocities induced by wave action at various depths. In the case of drilling from an anchored vessel, design problems will require knowledge of such quantities as the vertical and horizontal displacements to be expected, the frequency of occurrence of various wave lengths and periods to be considered in designing vessels for minimum roll and pitch, and the forces to be expected on anchors and cables. Efficient planning, accurate cost estimates, and realistic drafting of contracts and specifications for exploratory, drilling, and supply operations all require knowledge of the height of waves which limit operations of dredges, supply, and construction vessels, and the frequency and duration of periods when waves occur above and below these limits.

Two methods of approaching the problem of wave motion suggest themselves:

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either prevent or dampen wave motion, or predict and make allowances for it. The former approach has resulted in the use of oil slicks, compressed air jets,[3] and the building of temporary[3] or permanent breakwaters to dissipate wave energy. However, the energy involved in wave motion is so great that an attempt to dampen the waves in deep water is rarely economical. Hence the second alternative, making allowance for wave action, appears to be the more practical approach.

The planning and execution of amphibious landings in the recent war stimulated extensive research in the problem of long range estimation and short range forecasting of wind waves, swell, and surf. These studies were carried on principally by the Scripps Institution of Oceanography and the Department of Engineering of the University of California; the Woods Hole Oceanographic Institution; the Beach Erosion Board of the U. S. Army Engineers; the Air Weather Service of the U. S. Air Force; the Hydrographic Office of the U. S. Navy; and the British Admiralty. The results of these researches are now, for the most part, unclassified and available for general use. They not only permit forecasting of generation and decay of waves[3] in deep water, but also provide an explanation of the complex wave transformations which occur in shallow coastal waters. For example, Figure 2 shows the Long Beach, Calif., breakwater damaged by severe breakers in April, 1930. Stones, ranging in weight from four to 20 tons, were dislodged by high waves apparently "focused" on the outer tip of the breakwater. The circumstances were particularly unusual because only a light wind was blowing, and the sea offshore and in other areas of the bay was calm.

Fig. 3, prepared by O'Brien,[4] illustrates how this unusual situation occurred. As deep water waves move into shallow water, their forward velocity decreases, resulting in refraction of the wave fronts into an orientation more nearly parallel to the bottom contours. Such refraction concentrates wave energy over submarine ridges, causing the waves to increase considerably in height. The submarine ridge off the Long Beach breakwater caused an intense concentration of wave energy when swell, produced by a Southern Hemisphere storm, approached from the southeast. The heavy lines of Figure 3 show the "focusing" of wave energy at the breakwater. The energy in segment c-d (21 nautical miles) along the wave front in deep water was concentrated along a segment c'-d' (0.1 nautical mile) when the wave energy moved toward the breakwater. This caused waves with a two-foot height and 2000-foot wave length, so flat as to be imperceptible offshore, to heap into breakers approximately 12 feet high at the breakwater. This particular "post-mortem" makes obvious the necessity for careful investigation of all possible wave conditions at each proposed structure.

Another striking example of failure of marine structures through wave action was the destruction of the Loebnitz piers on Omaha Beachhead, Normandy. Waves averaging only eight to ten feet in height caused this disaster. The destruction which occurred about one week after completion is illustrated in Fig. 4.

Tidal Action

Tides, the long period waves resulting from gravitational forces exerted by the sun and moon, have been predicted by mathematical methods for several decades. These predictions of tidal level, prepared more than a year in advance by the U. S. Coast and Geodetic Survey, provide extremely accurate forecasts of water level when the ocean surface is not affected by strong winds (storm tides) or unusual wave types (seiches and tsunamis).

Storm tides, resulting from extreme variations in atmospheric pressure combined with "sloping" of water due to the tangential stress of winds, produce extreme deviations from the predicted tide level. The greatest hurricane destruction along shore usually results from the storm tide rather than high wind speeds. In the Galveston hurricane of 1900, the water level rose 15 feet above mean low water, the rate of rise being approximately 1.4 feet per hour.[5] The tremendous damage wrought under such conditions is not only caused by the rise in water level permitting wave action to extend farther inshore but also by unusually strong, erratic currents. Although present knowledge of storm tides is largely empirical, the designer and planner can be provided information regarding their frequency, height, rate of rise, current velocities, the extent of wave penetration inland, and associated destruction.

Variations in water level may result from the "sloping" of the water surface by winds of less than hurricane force. Along the Gulf Coast, the lowering of the water level in shallow bays during periods of strong offshore winds, such as "Northers," is frequently a serious navigational hazard. Deviations from the normal tidal levels have been observed to be of the order of magnitude of one to two feet with winds of 30 miles per hour and two to four feet with winds of 50 mph. Research on this sloping phenomenon has been carried out by Palmen and Laurila[6] in the Baltic area and by the Coast and Geodetic Survey along U. S. coasts. When dredging is necessary to maintain navigable water, the "sloping" effect must be considered in determining the depth of cut.

Seiches, standing waves induced in an enclosed or partially enclosed basin by variations in atmospheric pressure or tidal action, may result in extreme variations in water level. In the Bay of Fundy, for example, a standing wave superimposed on tidal variations causes an extreme range in water level of about 50 feet.[7] Seiches of appreciable magnitude do not occur along the Gulf Coast. However, the problem of seiche action may arise in the development of other oil-rich provinces offshore.

The possibility of tsunamis, long period waves generated by earthquakes and inaccurately called "tidal waves," is rather remote in the Gulf area, this region being sheltered from tsunamis originating in other waters, and not itself being a likely spot for major earthquakes. The data now available regarding characteristics of tsunamis permit an evaluation of their height, period, velocity, and a determination of coastal locations at which tsunami wave action will be concentrated.

Currents

The ocean is not only in a constant state of vertical motion in its upper levels as a result of gravity waves, but is also in continual horizontal motion throughout much of its depth. Currents in the Gulf, ranging in magnitude from the strong Florida current to barely measurable coastal eddies, will be of both help and hindrance in offshore work. Figure 5 shows the general surface current regime of the Gulf of Mexico. Superimposed on this "average" current regime are day-to-day variations resulting from changes in wind and wave action on the surface. Currents will be an important factor in design because of their effect in scour and deposition on the beaches, bottom,

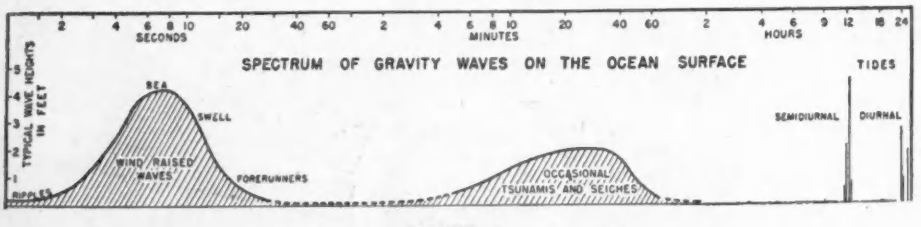

FIGURE 1.

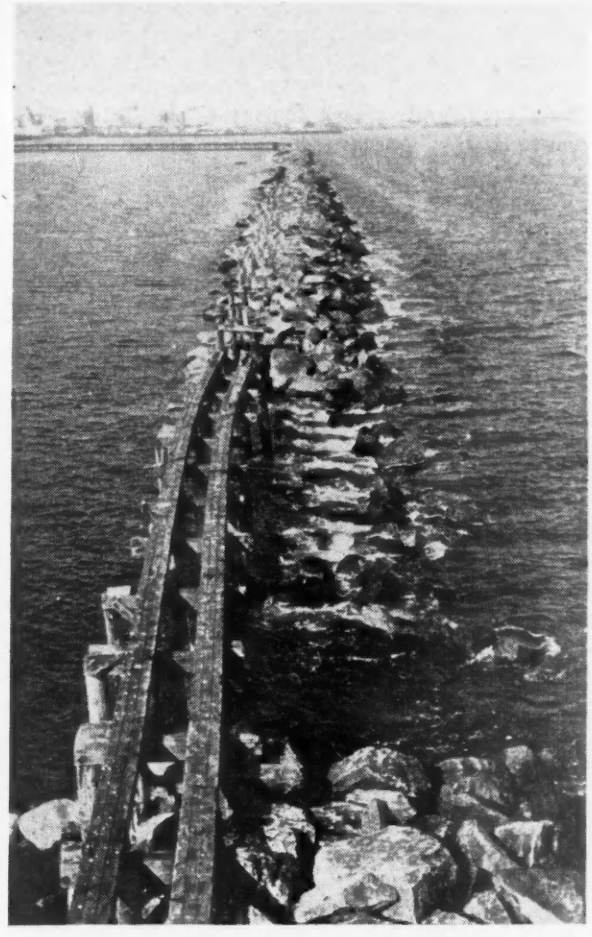

FIGURE 2. Long Beach breakwater damaged by severe wave action in April, 1930.
Photo by Department of Engineering, University of California

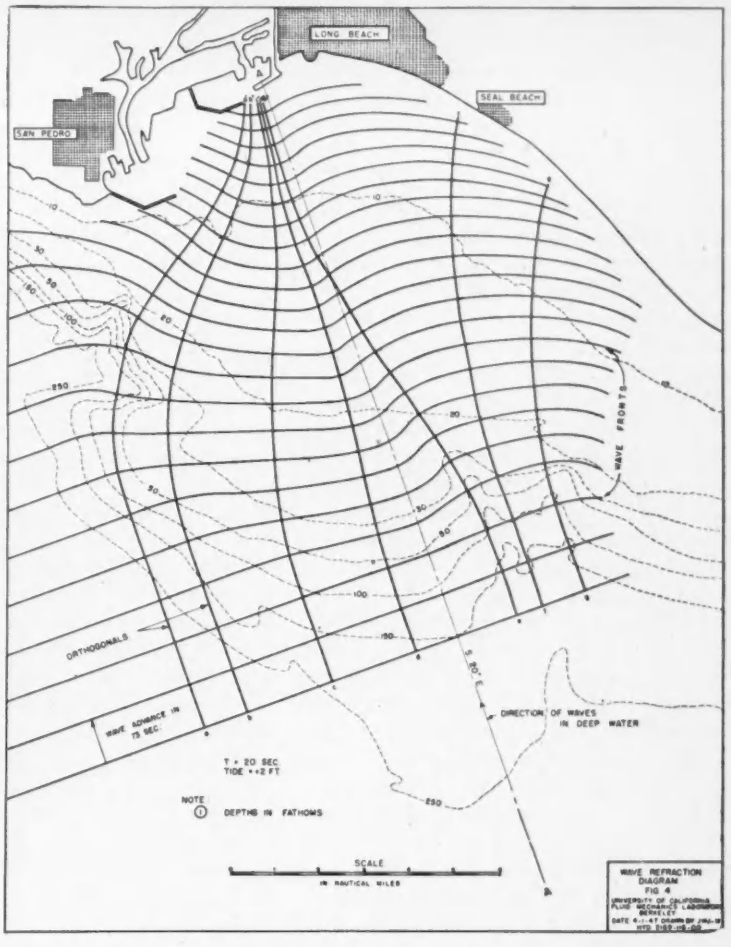

FIGURE 3. Refraction diagram of San Pedro Bay, California, for waves approaching from the southeast with a period of 20 seconds.
After O'Brien

and offshore bars. Since many of the Gulf currents are near the critical speed required to transport the finer-grained bottom sediments, slight changes in the speed of bottom currents will result in alterations in the pattern of erosion and deposition. In addition to the relatively gradual variations in bottom topography caused by current action alone, rapid changes occur in storms when waves of considerable height cause oscillatory motion of the water at the ocean bottom. This "stirring" places a considerably greater than normal load of sand and silt in suspension which then can be transported by relatively weak currents.

Model and wave tank techniques developed by the Beach Erosion Board and the Waterways Experimental Station of the U. S. Engineers, the Department of Engineering of the University of California, and the Woods Hole Oceanographic Institution are particularly adapted to determining the effect of current action on marine structures. Model studies are generally expensive but it is extremely desirable to determine, in the design stages, the expected durability of construction and dredged channels and their effects on neighboring beaches and bottom.

Marine structures such as jetties, breakwaters, and channels, intended to alter the normal oceanic regime, have been constructed for centuries, usually at high cost, and frequently have failed to accomplish their objective. Not only is the life of such structures oftentimes extremely short but also unexpected, and disastrous alterations in the oceanic regime have resulted.

Classic examples of the effect of tampering with wave and current forces without full knowledge of local conditions were several breakwaters constructed along the Southern California coast. At Santa Barbara, for example, a breakwater constructed in 1929 interrupted the normal eastward transport of beach sand in the vicinity and resulted in accumulation of about 2,700,000 cubic yards of sand inshore from the breakwater, and nearly complete erosion of sand along ten miles of beach to the east.[8] As a result of the beach erosion to the east, wave action penetrated farther inshore, causing extensive destruction to shore property. The net result of ignorance of oceanic processes in this case was costly litigation and the necessity for remedial construction which included dredging 700,000 cubic yards of sand.

Although there is a vast amount of current data available, it is probable that for very few localities are such data sufficiently complete to be of great value in design. In cases where design data are required for costly construction work, an oceanographic survey will be warranted. Current observations and bottom samples taken on the location combined with analysis of surf data will pave the way for a model study to determine the extent of scour and deposition after construction.

Another problem requiring knowledge of currents which will certainly arise is the disposal of drilling wastes and sewage. At sea or along the coast, sewage or other wastes in suspension are commonly dumped into the water and forgotten. This procedure is simple and effective in those areas where the mixing rate and current regime are favorable for rapid dilution of the wastes. In other areas, however, as several city sanitary departments have discovered, such wastes may turn up in unexpected places, and require the quarantining of beaches or condemnation of sea food. In planning for disposal of water-dissolved or water-suspended wastes, the designer should consider the expected current transport while the wastes are

undergoing diffusion to a harmless concentration.

The disposal of oil wastes directly into the water, in any but small amounts capable of rapid oxidation and emulsification, will probably be out of the question. The beaches of the East Coast, still soaked by oil from torpedoed tankers, are impressive examples of the permanence and severity of oil contamination. One rather ominous note in this connection is that a subsurface blowout may result in contamination and fire hazard of gargantuan proportions.

During the attack on Pearl Harbor, thousands of barrels of bunker oil spread from the damaged ships, finally producing a six-inch layer over the harbor. The serious fire and contamination hazard required that this oil be removed. No more satisfactory method could be devised than a vast scale "mopping up." The oil was drawn into deeper pools by booms dragged across the water and pumped off the surface. If any large amounts of petroleum escape from the offshore wells, it undoubtedly will be necessary to perform some similar "mopping up" operation under the more difficult open sea conditions. A knowledge of currents and waves will be essential in formulating plans to cope with any such eventuality.

Marine Biology

It appears that there will continue to be unavoidable conflict between the oil companies and the fishermen until it is determined to what extent offshore exploration and drilling operations are affecting the habitat of oysters, shrimp, and game fish. If litigation arising from offshore operations is to be minimized, it is necessary that oceanographers, cognizant of the life habits of commercial marine organisms, make quantitative surveys, "before and after" any offshore drilling. These surveys, which would include seasonal population studies and associated physical and chemical observations, would indicate the extent, if any, to which oil company operations were detrimental to marine life. The oil companies probably will be the scapegoats in the event that any extreme mortality in marine life occurs during offshore work. As a result of negligible damage to marine life caused by seismograph operations offshore, law suits involving several million dollars already have been threatened against several of the major oil companies. If, by chance, there shoulld be an oceanographic disaster along the Louisiana-Texas coast comparable to the "red tide"[9] which recently affected the southwestern Florida coast, the public reaction to such little-understood conditions might be directed against the oil companies' offshore activities. The "red tide" along the Florida coast, resulting from an extensive overpopulation of the dinoflagellate, *Gymnodinium,* has caused such widespread destruction of marine life that bulldozers were required to bury the decaying fish thrown up on the beaches. One of the most disagreeable features of this outbreak was the diffusion inland of throat irritating aerosols originating in the affected area.

The effect of environmental fluctuations upon the commercial fish and shellfish of the Gulf coastal region has been studied by such agencies as the U. S. Fish and Wildlife Service and the conservation departments of Louisiana[10] and Texas. To be of value to the oil companies, their work must be expanded quantitatively with controlled tests and surveys to determine short-and long-range effects of environmental change, both from natural and man-made causes. The present practice of assigning state-hired biologists at company expense to serve in an advisory capacity with field crews, as is now being done with seismic parties, is inadequate to protect oil company interests. Such practice results in a haphazard dissipation of efforts which will result at best in a disorganized accumulation of field observations, unsuitable to establish definitely the effect of oil company operations on marine life.

As a model of a program sufficiently comprehensive to provide useful quantitative results, the California sardine research project may be cited. Due to a sudden and unforeseen decrease in the sardine catch on the Pacafic Coast, an oceanographic research program was initiated by the fisheries and will be supported partially by a special tax levied on the sardine catch at the request of the fishermen. This investigation conducted by the Scripps Institution of Oceanography will utilize three ocean-going vessels and the requisite shore laboratories on a year-round basis to determine the causes of fluctuations in the sardine catch. Similar fluctuations in the shrimp and oyster catches on the Gulf Coast are now occurring and being ascribed to seismic work without thorough investigation of the many factors which affect spawning, growth, migration, and death rate. An oceanographic study comparable to that on the Pacific Coast would permit the causes of fluctuations in commercial catches to be definitely assigned, rather than blamed haphazardly, on the oil industry.

Relative to other nations where fishing is a vital enterprise, the efforts of the U. S. to study the marine biological environment have been extremely limited. Japan, for example, operated 30 fishery research vessels on a full-time basis immediately before the war,[11] while the U. S. operated only two,[12] neither of which was ocean-going nor based in the Gulf of Mexico. Although plans have been drawn up to expaand fishery research in the U. S., the results will not be sufficiently comprehensive or immediate to be of assistance in discouraging expensive litigation during the next few years. Thus, immediate action will have to be taken by the oil companies themselves if legal evidence is to be acquired for their defense.

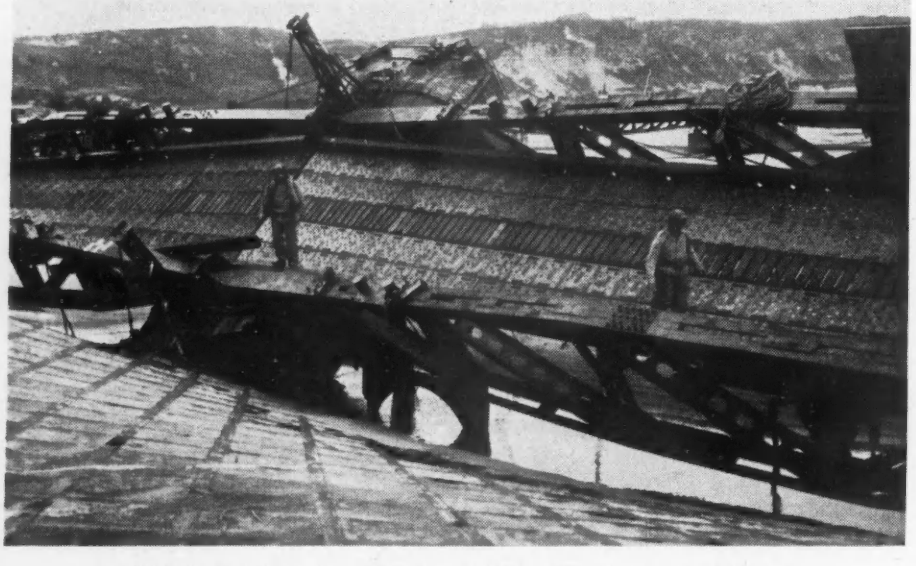

FIGURE 4. Wave destruction on Loebnitz Pier, Omaha Beachhead.
Army Signal Corps photo

Fouling

Submerged wood, metal, and concrete are subject to the attachment of various types of marine organisms (Figure 6). The rough and heavy coverings which result may be detrimental to diving operations, demolition or repair of the structure, operation of submerged valves, weight-carrying capacity, and the efficiency of boat and barge operation. In the case of wooden and concrete

structures, these organisms not only attach themselves, but also may bore into and seriously weaken the structure.

Wide variations in temperature, salinity, transparency, and other factors affecting growth of marine organisms are to be found in coastal waters, so that problems experienced in fouling at one location may be greatly different from those at nearby locations or at the same location after a period of time. For example, although parts of the San Francisco Bay area enjoyed immunity from the native wood borer before 1913, the introduction of the infamous European shipworm, the teredo, plus an abnormally dry year that caused an increase in the bay's salinity, resulted in more than 25 million dollars damage to bay structures in the following few years.[13]

During the war years, about $6 million were spent by the Navy in research on anti-fouling paints. The researches included such studies as the determination of the geographical distribution of fouling organisms, their methods of attachment, the types of structures and materials most likely to be affected by fouling, protective coatings, and galvanic action of the copper-bearing paints. Practical investigations were made concerning the fouling of ships' hulls, mines, mooring cables buoys, anchors, chains, and permanent underwater structures.

One important discovery resulting from this research was the determination of how paint specifically prevented fouling. This seemingly simple problem had baffled marine designers for about 23 centuries. Through this discovery, that anti-fouling properties of paints depended upon the rate at which their toxic compounds leached, chemical tests were devised to predict the anti-fouling effectiveness of a new paint before it left the laboratory. This permitted the development of new paints according to strict specifications, and took the chemistry of anti-fouling paints out of the trial-and-error stage. As a result of the development of anti-fouling paints during the war, the efficiency of ship operation was greatly increased. Dannenfelser reports[14] that development of plastic anti-fouling paints ranks along with the development of radar in contributing to naval successes in the Pacific.

Much of the research in this field has been carried out under the direction of the Woods Hole Oceanographic Institution and the Mare Island (Calif.) Navy Yard. Their work, plus that of the paint laboratories and other agencies, is being summarized in the forthcoming volume, "Marine Fouling and Its Prevention."[15] Oceanographers believe that the biological phase of the fouling problem is at last understood. Future progress in the prevention of fouling must come largely from industrial paint laboratories, the immediate problem being the extension of the life of anti-fouling paints beyond their present span of two years.

Corrosion

The long-standing problem of corrosion will become particularly acute when structures and equipment are exposed to sea water and salt spray. The oil companies' experience in holding corrosion to a minimum can be supplemented by the marine engineers' knowledge acquired during 70 years of steel ship maintenance, the results of research carried on during the past ten years by the metals industries, and the recent research by the Navy and organizations such as the Corrosion Research Laboratory at the Illinois Institute of Technology.

The marine engineers' experience has produced a valuable compendium of

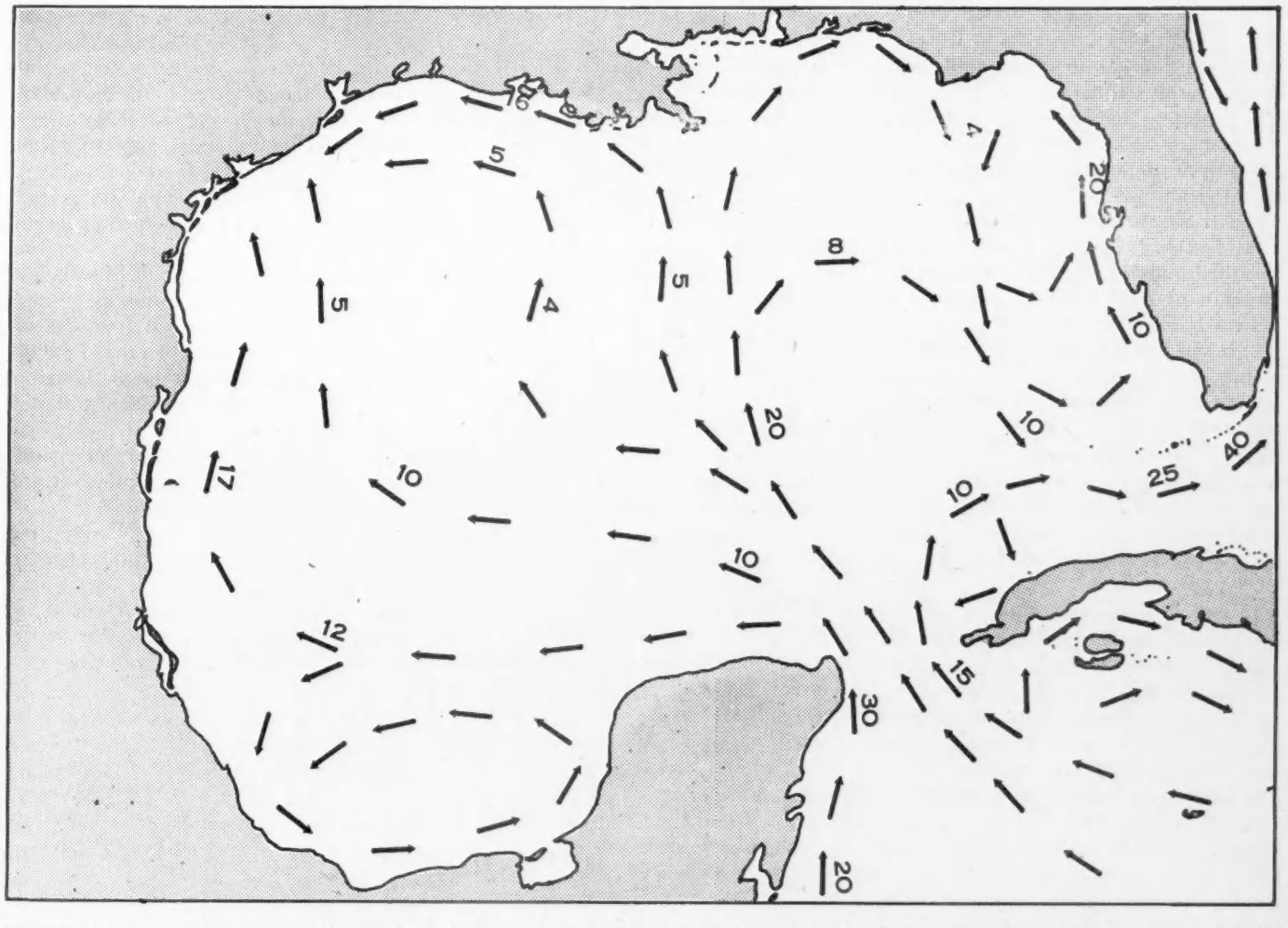

FIGURE 5. Average surface currents in the Gulf of Mexico for April. Superimposed are day-today variations resulting from changes in wind and wave action on the surface. Numbers indicate amount of drift in nautical miles per day. After U. S. Hydrographic Office Pilot Chart 3500

FIGURE 6. Bell buoy fouled by marine organisms after three years of immersion off Cape Cod.
Photo by Woods Hole Oceanographic Institution

practice for preventing and minimizing corrosion of standard structural steels. The "painting and chipping" procedures followed on ships are an example. The electrolytic action of sea water on a grand scale was observed years ago, when it was attempted to combine the anti-fouling features of the copper-sheathed hulls of wooden ships with the strength of steel hulls. It was demonstrated conclusively that electrolysis progresses rapidly when such dissimilar metals are in contact in sea water. Another conclusion based on practical observation was that rust is an excellent catalyst for the oxidation of iron. Ship engineers learned this when investigating the possibility of permitting rust to accumulate in the hope that it would provide a "protective coating" for the steel underneath.

In 1935, International Nickel Company established an outdoor corrosion testing laboratory at Kure Beach, North Carolina.[10] The initial purpose was to compare under actual marine conditions the corrosion resistance of low alloy steels with carbon steels. The laboratory soon outgrew its original function, and now comprises a $300,000 research investment, which has been used in testing more than 10,000 specimens. One interesting feature of this facility is that it is now supported and utilized by four competitive producers. The importance to the metals industry as a whole of solving the problem of corrosion outweighed competitive considerations. As a result of research by the metals industry like that carried on at Kure Beach, corrosion-resistant metals have been developed such as stainless steels, and aluminum alloyed with magnesium, silicon, or chromium. In designing marine structures, cost of corrosion-resistant steels should be compared with that of standard steels in terms of the increased life of the former.

The plastics and plastic paints for marine structures developed for the Navy during the war, mentioned previously in connection with fouling, are also corrosion resistant. Each of the plastics developed has its advantages and limitations, and while none is a cure-all for corrosion, they represent a large step forward.

Existing know-how can solve the corrosion problem on offshore structures to a great extent. The problem, as far as designers of offshore structures are concerned, is primarily in assembling it from various sources and putting it to use.

Water Supply

From the fresh water standpoint, an offshore drilling structure is a desert island. Not only is the sea water unfit for human consumption, but the chloride content is usually too high for use with barite drilling muds. Fresh water for human consumption is a minor problem, but a continuous and adequate supply of water of low chloride content for drilling will constitute a major problem. Several possibilities should be investigated; water supply from a shallow well at the rig, barging, or pipe line from shore, collection of rainfall, distillation; and, as a suggestion at present prohibitively expensive, chemical treatment of sea water for removal of salts. Possibly the long term solution is the development of drilling muds which will perform satisfactorily when used with sea water. In the immediate future, however, the most convenient fresh water source is the shallow well at the rig. At many locations, a shallow well will yield only salt water or an inadequate supply of fresh water, and the problem resolves itself into a comparison of the costs and feasibility of other fresh water sources.

In considering rainfall as a fresh water source, the meteorologist can provide information regarding the minimum monthly or weekly rainfall which can be expected at the location.[11] This base figure can be used to determine the amount of the reliable rainfall supply. Distillation has been extensively used on ships and dry islands for water supply. The Navy has found, for example, that the volume ratio between

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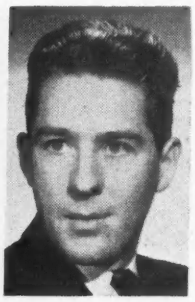

ALFRED H. GLENN was a captain in U. S. Army Air Force and won the Air Medal for weather reconnaissance. His activities include research in tropical meteorology at RAAF Meteorological Service Headquarters in Melbourne; meteorlogist with Air Weather Service; member of Panel on Oceanography, Research and Development board; member of American Association for the Advancement of Science, American Society of Civil Engineers, American Meteorological Society, and American Geophysical Union.

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oil required and fresh water produced for island distillation units is approximately 1 to 6.[18] The output/input ratios for various distillation units have been determined so that a cost estimate of distilled water can be readily prepared. Chemical treatment of sea water for removal of salts has been perfected for use in production of small quantities of drinking water on life rafts. However, the cost is prohibitively high where large amounts of water are required since silver is used as the precipitating agent for chloride ions. The possibility of developing cheaper chemical methods is relatively remote.

Heretofore unmentioned is the possibility of the drilling location being situated in a zone of low surface salinity. At considerable distances from shore, this possibility is remote, but close to the Gulf Coast near the mouths of the large rivers, an oceanographic survey near the location may turn up a fairly persistent stream of low chloride content.

Conclusions

The examples of the utilization of oceanography described in this paper indicate some of the more obvious problems which designers and planners of offshore work must solve if safety and continuous operation are to be maintained without excessive over-design. In many cases the present techniques and data of the oceanographic profession are ample to permit a direct answer to construction and maintenance problems. In others the solutions may be worked out by drawing upon the oceanographic experience with similar problems encountered in the past. In some cases the problems arising in design work will lie on the frontiers of oceanographic knowledge and special research may be required to achieve a solution. Oceanographic research is expensive, frequently involving the use of models[19] and specially equipped vessels;[20] but, as has been proven repeatedly in the past, the case will rarely arise where over-design or a trial and error solution is less expensive than research permitting direct solution of design problems.

Because of the extensive research program of the armed services, the present oceanographic facilities of the U. S. are engaged at near capacity. Until the recent war the demand for oceanography in engineering was relatively limited and the field developed primarily as a "scientist's science." As in the case of other technical fields, the shortage of personnel trained in various phases is particularly acute, and there is little hope that this shortage will be alleviated in the immediate future. To provide oceanographic assistance to oil company staffs, several temporary expedients are possible. There are a number of governmental and educational institutions which can provide assistance to a varying degree. In addition, personnel associated with these institutions may be available as consultants. Training of company personnel at the various oceanographic institutions may also be feasible.

If the offshore program develops to the extent frequently predicted, the most practical manner of solving the oceanographic problems would be the expansion of existing oceanographic facilities in the Gulf Coast area or perhaps the establishment of an oceanographic institution which would specialize in the applied phases of oceanography. Such facilities could draw financial support from interested companies and undoubtedly partake in research contracts sponsored by the Department of National Defense while providing specialized oceanographic information for the Gulf Coast such as is now provided by the Scripps Institution of Oceanography and the University of Washington Oceanographic Laboratories for the Pacific Coast, by the Woods Hole Oceanographic Institution for the Atlantic Coast, and by the Division of Oceanography, U. S. Hydrographic Office for waters in which the Navy operates.

ACKNOWLEDGEMENTS

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CHARACTER OF PORES IN Oil Sand

by

HARRY M. RYDER

ALL OIL produced from a sand has moved through pores in that sand. All oil retained in an oil sand is held in those pores, almost all of which are of capillary dimensions. The shapes and sizes of the pores and the nature of the solid surfaces exposed to liquids (i.e., preferentially wet with water or oil) therefore influence the quantity of oil moved, the rate at which it moves, the forces required to move it and the quantity of oil retained in the sand after movement has ceased. The influence of the pore characteristics is even greater where two or three fluids are jointly concerned, as is usually the case.

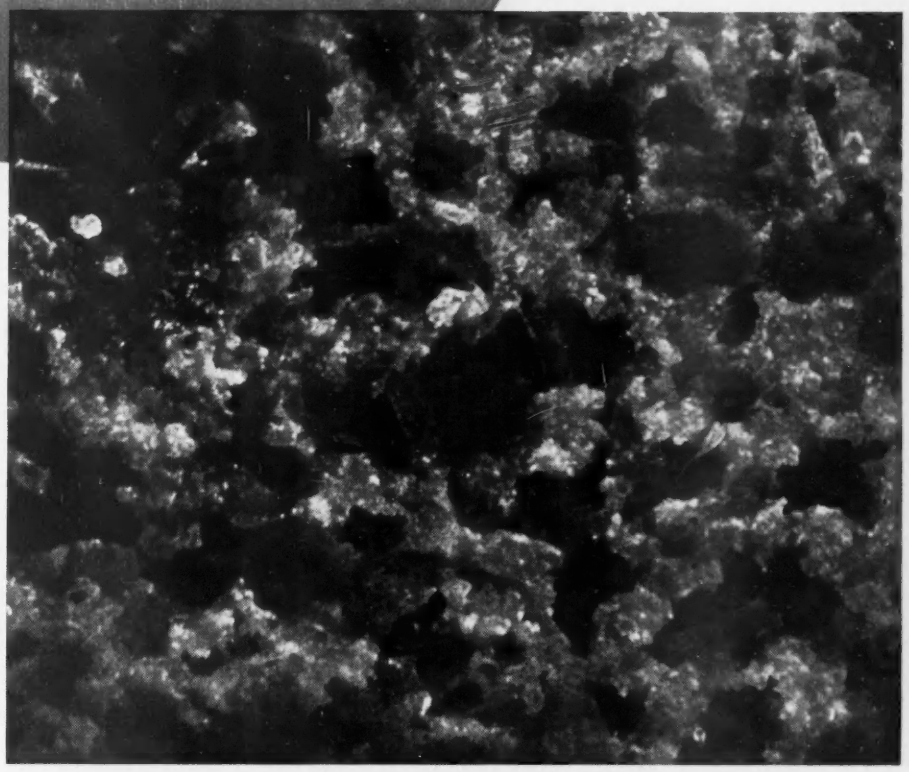

FIGURE 1. Wax Cast. Pores of Bradford Oil Sand. X 64. 20 mm Microplanir lens.

THE shapes and sizes of oil-sand pores and the nature of the pore surfaces are matters of importance in the economics of oil production. Further, engineering planning for the most effective production (greatest ultimate production, lowest unit cost, desired rate, etc.) of oil from a given sand body needs to build on a knowledge of all controlling factors, including the characteristics of the sand pores. It is the purpose of this article to present a method for the determination of certain characteristics of pores and certain findings resulting from the applications of the methods discussed.

Determination of the shapes and dimensions of pores cannot be accomplished satisfactorily by observation of a piece of sand or of thin sections under the microscope. This is so because the third dimension is obscured. The shapes and sizes of sand grains affect but alone do not determine the shapes and sizes of the pores. An alternative approach is the preparation of a cast of the pores and the subsequent examination of that cast. This procedure was first suggested by Nutting:[1] "It is not difficult to make a wax cast of the pores in sand. I have made several by soaking a lump of sand in melted cerecin wax, then dissolving out the sand with hydrofluoric acid . . . It is hardly worth while to reproduce such a print for the wax cast, under a microscope, has precisely the appearance of a slice of bread." That was in 1929. One of Nutting's casts was examined by the writer. Since then, Francis R. Conley of Ryder Scott Company has prepared a number of wax pore casts from Bradford sand of known permeability and porosity characteristics.

An examination under the microscope of casts from Bradford sand is very revealing. The pores are characteristically very thin, relatively very wide and essentially flat "crevices." They are oriented in all directions and connected into a three-dimensional network which includes small "rooms" ("Precisely the appearance of a slice of bread"). Most of the thin, wide, crevice-shaped pores are of the order of one micron (0.00004 inch) in thickness. The thickness of some is less than one-quarter micron, as evidenced by the presence of interference patterns on the wax when viewed through the microscope. The areal dimensions of the flat pores are mostly between 0.03 and about 0.2 millimeter (0.0012 and 0.08 inch), averaging perhaps 50 to 100 times the thickness of the pores.

In the sand studied, the very thin, wide pores provide most of the pore volume. The fluids in moving through the sand move through such pores. It is these pores, therefore, that provide resistance to the movement of fluids through the sand. Their dimensions and the number in a unit cross-section should be dimensional factors determining permeability values of sand.

Pore casts have been made of Bradford sands of permeability values ranging from less than one millidarcy to

more than 100. Examination of them suggests no relation between the permeability value and the number of pores per unit area, or between the permeability value and the areal dimensions of the pores. The thickness of the openings appears to be a controlling factor in the permeability value.

Figure 1 is a photomicrograph of a wax cast made from Bradford sand. Because of the random positions of the thin, wide pores and because of the foreshortening effect of the special lens used to obtain depth of field, few of the pore casts can be viewed end on. However, the very thin wafer-like shape of the casts of the pores is obvious. A careful study of the picture will reveal the exceeding thinness of some of them. To better illustrate the thinness, Figure 2 is presented. This protomicrograph was made using the usual 16-mm objective lens, resulting in very slight depth of field. In this illustration the thickness and width of the pore casts are readily observed.

By far the most satisfactory observation of pore casts can be made only with the aid of a stereoscope. The old-fashion "parlor-table" variety is sufficient. Figure 3 is included for this purpose. This is a stereoscopic photograph of a cast of pores in a piece of 29-millidarcy Bradford sand, magnified 64 diameters. The characteristic shape of the pores is clearly revealed in this three-dimensional view. Even some of the rock-candy-like parts of the cast, upon close examination, are seen to be very thin pores which followed the surfaces of small, angular grains. The holes in the cast locate the points of contact between sand grains. The very smooth, flat pores clearly indicate the crystalline surfaces formed during the process of cementation by the deposition on the sand grains of silica dissolved in the connate water.

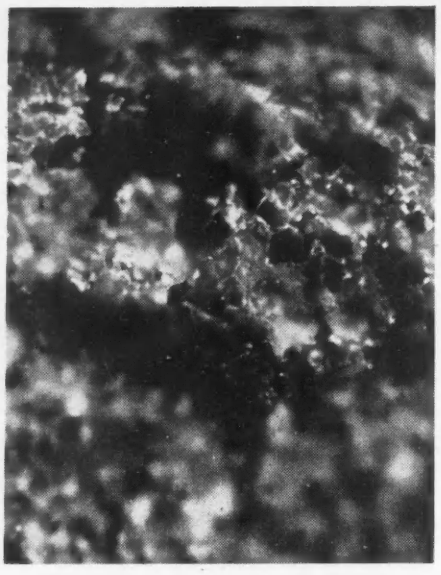

FIGURE 2. Wax Cast. Pores of Bradford Oil Sand. X 42. 16 mm ordinary objective lens.

The casts of the pores do not provide the only evidence of the characteristic shape shown here. Figure 4 is a photomicrograph of a thin section of Bradford sand. In this section the relatively long, very thin spaces between the sand grains are readily observed. As regards pores, the similarity of Figures 2 and 3 is striking.

As regards pore shapes, Figure 5 also supports the evidence of the casts. The conductivity of a capillary tube of circular section varies as the fourth power of the radius of the tube (Poiseuille's law). In the case of a very thin and wide conductor in the shape of a crevice, the conductivity to a fluid increases as the cube of the thickness of the crevice.[2,3] Klinkenberg[4] shows that $\frac{4c\lambda}{r} = \frac{b}{p}$. That is, the constant "b" is inversely proportional to r, the radius of the capillaries (pores) in an oil sand. Because Bradford sand pores have no radius, the more general term "size" (perhaps meaning the pore thickness) must be used and may be evaluated as the inverse of b in Klinkenberg's work.

If in a particular type of sand the principal resistance to flow occurs in pores of circular cross section, the true conductivity of that sand (permeability) should be proportional to the fourth power of the pore size, $\frac{1}{b}$. But if the principal resistance to flow occurs in very thin, wide pores, the permeability should be proportional to the cube of $\frac{1}{b}$. Accordingly, the curves in Figure 4 have been prepared.

For the Bradford sand curves, the "liquid" permeability value for each point has been determined from a series of permeability measurements by air flow at a series of pressures on a single sand plug in a manner similar to that described by Klinkenberg,[4] taking into consideration the curvature of the K-versus-$\frac{1}{P}$ curve. Most of these points, within a permeability range of almost 1000 to 1, fall remarkably close to the plotted straight-line curve. The slope of this curve is 2.91. It is therefore indicated that the permeability of the Bradford sand is proportional to the 2.91 power of the pore size. Yuster[5] presents data (credited to Nielsen, Smith and Yuster[6]) from which a similar curve for the Bradford sand may be prepared. That curve has a slope of 2.96 and would plot somewhat lower than the Bradford curve in Figure 4. The slopes of these curves are so nearly three, it is indicated that the dominant resistance to the flow of fluids through Bradford sand occurs in the very thin, wide pores observed; not through pores whose cross section approximates a circle or other geometric pattern.

Other sands, however, are not necessarily similar to Bradford sand in this respect. Data calculated from Table 9 in Klinkenberg's paper[4] are also plotted in Figure 4. The locations of the sources of the sands he used are not given. The slope of the curve plotted through these points is 2.78. It would appear that the resistance to flow is again dominated by very thin, wide pores, but not so completely as in the case of the Bradford sand.

The fact that Klinkenberg's core samples are "of different origin(s)" may account for the greater deviations from the curve. It also could render invalid the slope of the curve. But assuming that comparable methods were used in the preparation of the two curves, for the same size of pore Bradford sand has approximately five times the permeabil-

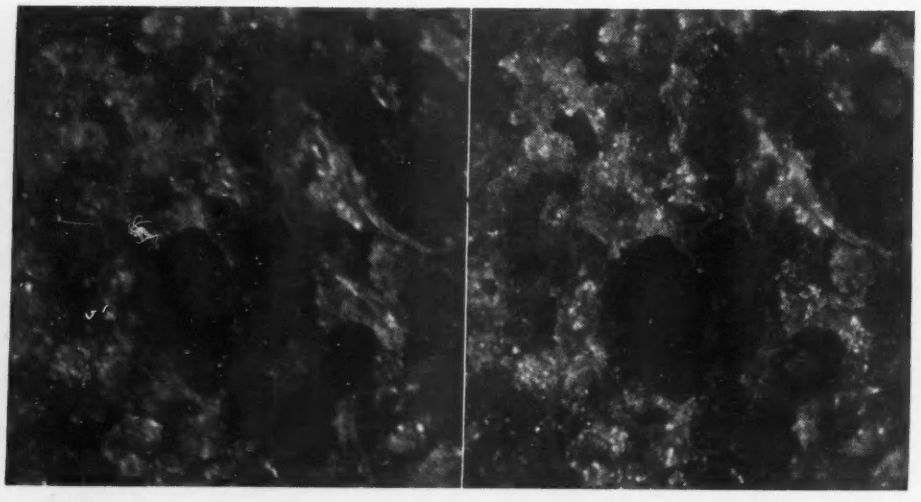

FIGURE 3. Stereoscopic photomicrograph. Wax cast. Pores of Bradford oil sand. View figure through ordinary stereoscope.

ity of the sand Klinkenberg used. That would indicate five times as many pores per unit area of flow section. And conversely, for the same permeability the pores in the sand Klinkenberg used are roughly twice the size of those in the Bradford sand. It is not to be expected that liquid movements and liquid retention would react similarly in these two types of sand.

Again, Yuster[5] presents data, credited to Krutter and Day,[7] relating to Venango (Pennsylvania) sand. From these data a similar curve can be prepared. The slope of the resulting curve is 1.46. Apparently the shapes of the Venango sand pores are quite different from those of Bradford sand and from those of the sand Klinkenberg used. Bradford sand (middle Devonian) and Venango sand (some 1200 feet above the Bradford) are different in other respects. Bradford sand is brown, Venango sand is white, of which more later. Bradford sand has been profitably water flooded. Waterflooding attempts in the Venango sand have failed.

Assuming that comparable methods have been used in the preparation of Krutter and Day's curve and that for the Bradford sand in Figure 4, the pores of these sands with permeability values of about 20 millidarcies are about the same size. But for permeability values greater than 20 millidarcys, the Venango sand has larger and fewer pores per unit area than Bradford sand of similar permeability. For less than 20 millidarcys Venango sand has smaller and more numerous pores per unit area. From shape and dimensional considerations it would be unsafe to assume that liquid movements and liquid retention would react similarly in these two types of sand.

The Nature of Pore Surfaces

The movements of water and of oil through pores of capillary dimensions may be greatly influenced by the preference the surfaces of the pores may have for being wet by water or by oil. To provide evidence as to the nature of pore surfaces, the pigment material of Bradford and Burkburnett (Texas) sands was investigated. Nutting had observed many years ago that the treatment with chromic acid of certain brown oil sands removed the brown hydrocarbon coating. Bradford sand, extracted with Butyl alcohol, carbon tetrachloride, or pentane remains brown. However, normally extracted (with pentane) Bradford sand when given an additional extended extraction with fresh pentane provides a very small but definite quantity of almost black, almost solid extract, but so treated has always remained a light brown.

Burkburnett sand (from North Burkburnett field) and pentane-extracted Bradford sand were treated with hydrochloric acid. The sands did not change color appreciably, nor was the acid appreciably colored. If any pigmented material (iron compounds) was removed by this treatment, the effect was not observable.

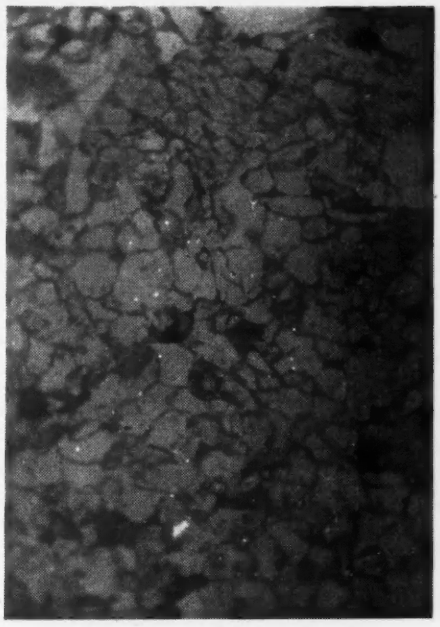

FIGURE 4. Thin section. Bradford oil sand. X 42.

Other pieces of this same sand, some of it crushed, were then treated with strong chromic acid. The resulting Bradford sand was glistening white; the Burkburnett sand was a very light buff. Examination of the Burkburnett sand under the microscope revealed the presence of an iron-oxide-colored stain on some grains. The subsequent treatment of this sand with hydrochloric acid resulted in the removal of the stain, and produced a white sand.

Some of the results of this work are illustrated in Figures 6, 7, and 8. From this work it is concluded that the dominant pigment in the extracted sands is organic and, at least in the case of the Bradford sand, the coloring of the pigment is intense. Referring now to Bradford sand, since extraction by all of several solvents leaves much of the pigmented material within the sand, it seems reasonable to conclude that the residual organic matter is not in solution in the oil just prior to extraction. The Bradford sand was put under pentane on the derrick floor within a few minutes of the time it was cut, and kept there until extracted, to avoid oxidation. It is reasonable to assume that the pigmented material is of petroleum origin. Therefore, it is logical to assume that the pigmented material consists, in part at least, of complex polar compounds which have been selectively adsorbed on the originally inorganic surfaces exposed in the pores. By the process of adsorption, therefore, the initially inorganic pore surfaces were converted to organic, oil-wet, hydrophobic surfaces.

The latter conclusion presupposes that the organic constituents had at some time direct access to the inorganic pore surfaces without the intervention of sufficient water or moisture to prevent the adsorption. Tests not yet reported show that the light ends of crude oil are materially soluble in water at elevated pressures. But those tests provided no similar evidence of solubility of the larger molecules. It does not seem reasonable that the heavy highly-pigmented polar compounds could have been dissolved in water and subsequently precipitated out on the pore surfaces.

For such adsorption to have taken place therefore requires the absence of interfering water from the affected pore surfaces. This could have been the case in the Bradford sand. The source beds of Bradford petroleum are not known. But it is known that a thick, black shale bed, "particularly rich in organic matter,"[8] occurs a few hundred feet below the Bradford sand. If the Bradford crude originated in that shale, it is possible that the crude oil migrated vertically to the Bradford sand reservoirs through open joint planes. Numerous joint planes are observable in the Bradford series sand exposure near Rushford, N. Y. Also, in testing thousands of Bradford wells, occasionally a well is found drilled through sand formation whose shale interbedding is all petroliferous, with no other wells nearby. Elsewhere no oil is found in the interbedded shale. The locations of the observed petroliferous areas of the shale "breaks" could be near joint planes which at some time served as passages for the migration of petroleum.

The presence of substantial quantities of oil in the sand would serve as an effective seal, holding the water co-occupying that sand. For the oil to have come in direct contact with the pore surfaces, much of the original water in the sand must have moved out prior to the entrance of the oil. That is, much of the water must have been removed by a process other than its having been driven out by the incoming oil. This could have happened. If the approach of oil was preceded by the movement of gas into the sand, that gas could have driven out some of the water and could have carried much more with it in the form of vapor.

During geologic time large volumes of gas could have moved through and from the sand through the very low-permeability overburden. Pirson[9] has shown that this process continues today, even

in low-pressure areas. The dissolved-salt content of the connate water in Bradford sand is in excess of 23 percent. Small halite crystals are occasionally found in the sand. Evaporation of the connate water in place is indicated. If gas moving through the sand caused such evaporation, that evaporation would have occurred most freely in the high-permeability beds of large area (through which the gas could move most freely). The sand beds of this type in Bradford now contain very small quantities of true connate water . . . 5 to 10 percent of the pore volume as compared with 40 to 50 percent connate water content in the close-by, very low-permeability sand beds of very small area.[10] There is almost no cross-bed movement of fluids today in the Bradford third sand. Fluid movement is confined to the bed of its origin (rarely more than a foot or two thick) by shale or mica interbeds, some no thicker than paper. Recently an excellent description of this sand has been published.[10]

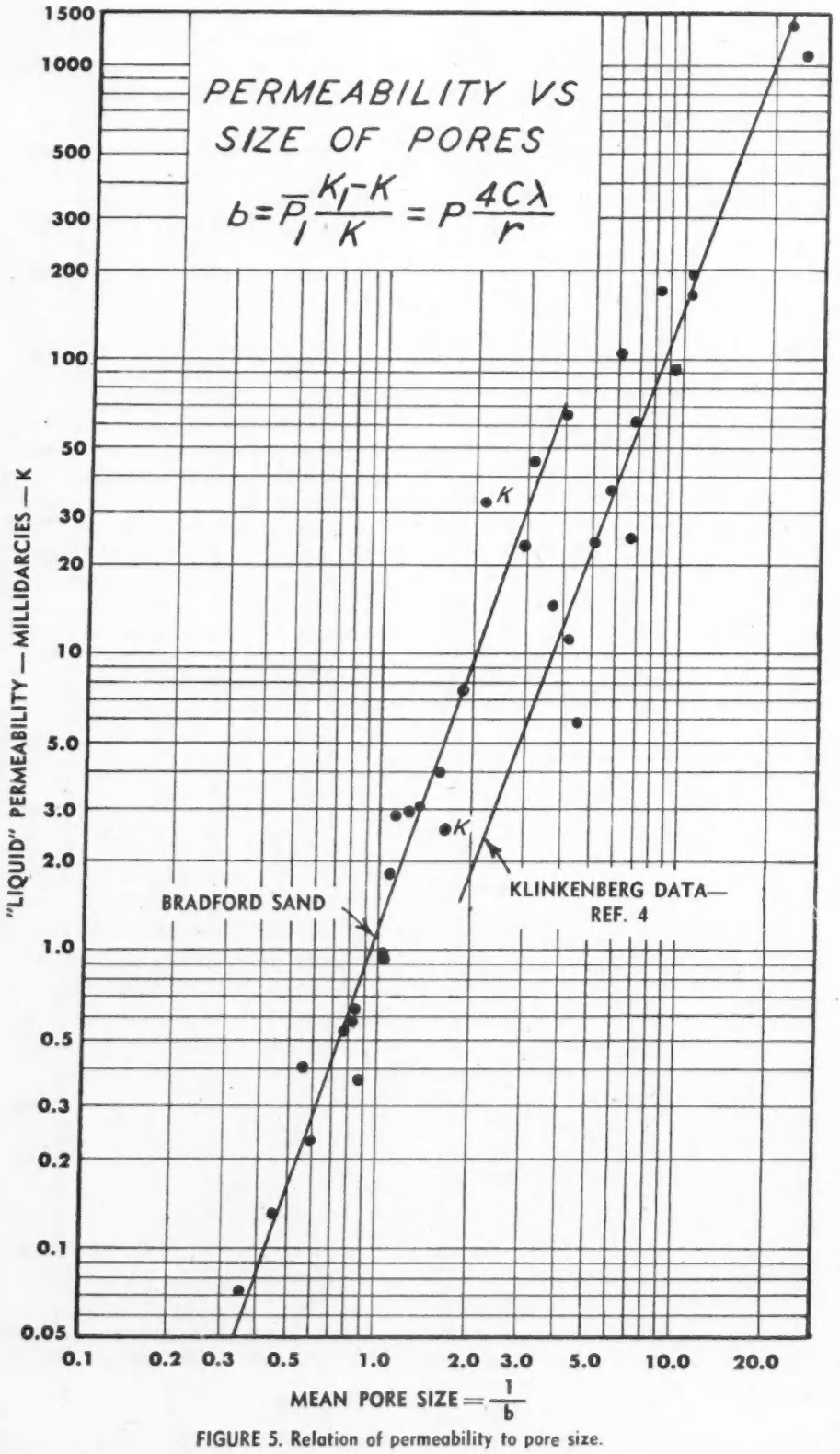

FIGURE 5. Relation of permeability to pore size.

The well-known Bradford "black" sand (reference 10, Figures 4 and 9) is a dark chocolate-colored bed, mostly of relatively very high permeability, located near the bottom of the third sand formation. As a continuous bed, it is by far the largest areally in the Bradford field. This bed contains very little true connate water. The intense organic pigmentation could have been the result of a large volume of oil slowly passing through it, perhaps over a very long period of time, to other parts of the field and perhaps to other beds. Such movements would expose it to a heavier-than-average adsorption of organic material on its exposed pore surfaces, hence more intense pigmentation.

It would seem, therefore, that prior to entry of oil into the Bradford sand the connate water content was greatly reduced in volume, partly by evaporation. Capillary forces would cause the remaining connate water to occupy the smaller cul-de-sacs, leaving the greater portion of the pore surfaces exposed and comparatively dry. Under these circumstances, the oil in entering the sand came in contact with much of the pore-surface area. On this area some constituents of the crude oil were adsorbed, providing the pigmentation observed in the Bradford sand. These surfaces were then oil-wet and still are preferentially wet with oil.

The whiteness of the Venango sand indicates that no organic material was adsorbed on the pore surfaces in that sand, although the Venango and Bradford crudes are quite similar (both Pennsylvania grade). This would indicate that oil never has been in contact with the pore surfaces; that the pore surfaces were covered with water at the time the oil arrived, and still are. Perhaps from the Venango sand water was driven out predominantly by arriving oil. That sand is water-wet.

Conclusions

From Bradford sand, with its very thin, wide pores, its brown, organic-material coated, oil-wet, hydrophobic pore surfaces, large volumes of oil have been profitably removed by water flooding. Prior to flooding, many of the very thin, wide pores are filled with oil from oil-wet wall to oil-wet wall. The driving water of a flood of necessity forces the oil out because the pores are too thin (mostly 0.00004 inch or less) for capillary and interfacial forces to permit the water to bypass the oil. Under these circumstances and within some real limits, the greater the pressure gradient the more oil would be expected to move out; the more effective the water-flood-

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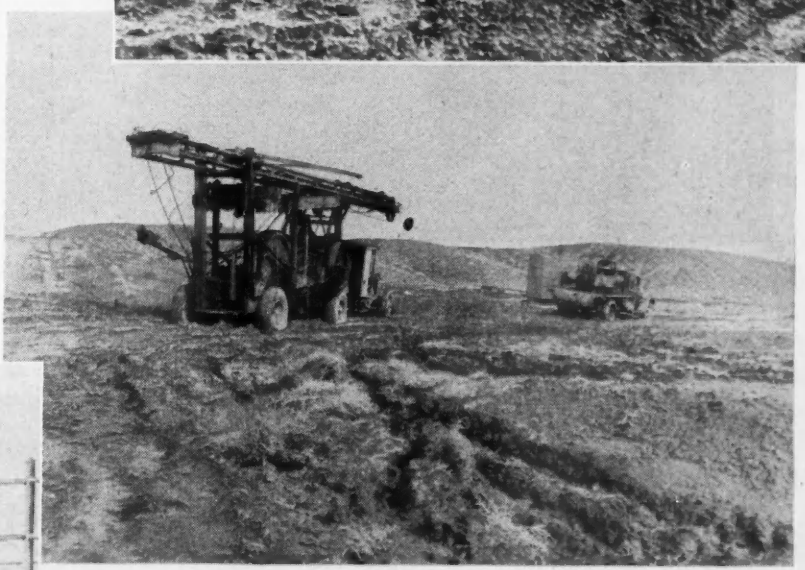

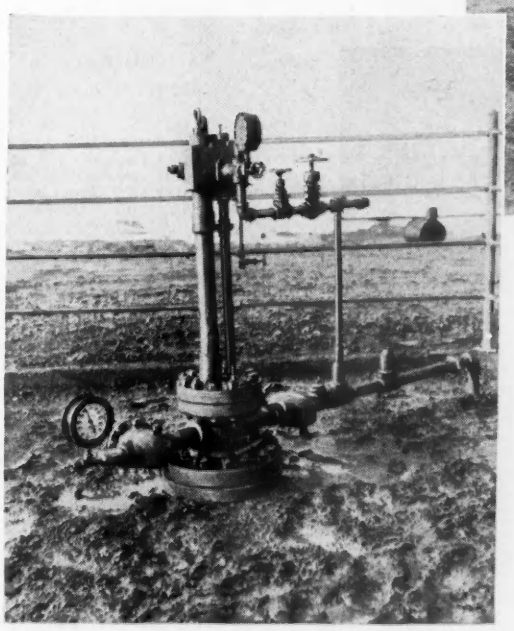

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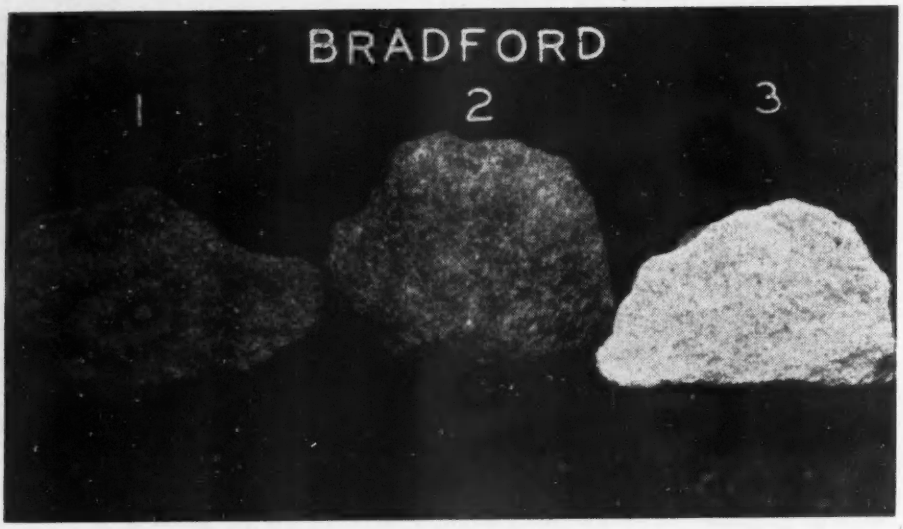

FIGURE 6. Bradford oil sand:
No. 1. Extracted with pentane.
No. 2. Treated with hydrochloric acid.
No. 3. Treated with strong chromic acid.

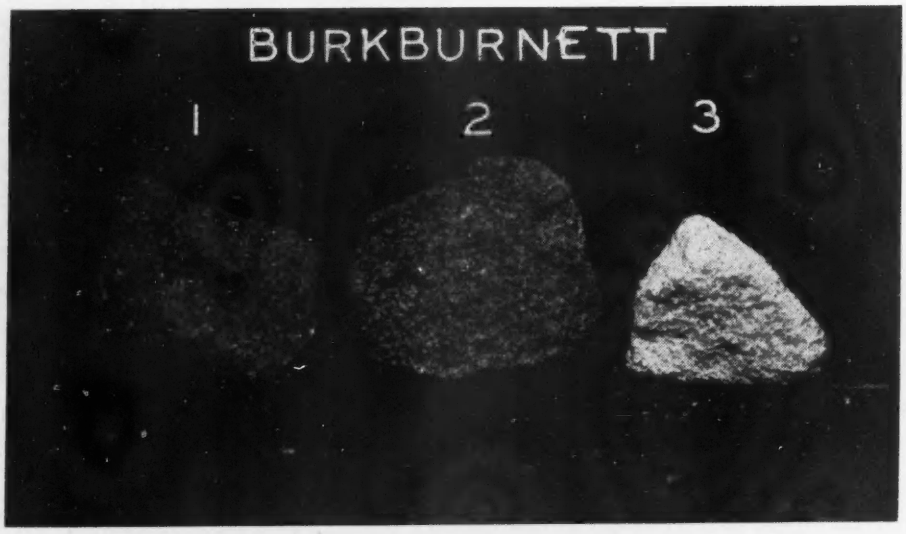

FIGURE 7. Burkburnett oil sand:
No. 1. Not extracted.
No. 2 Treated with hydrochloric acid.
No. 3. Treated with strong chromic acid.

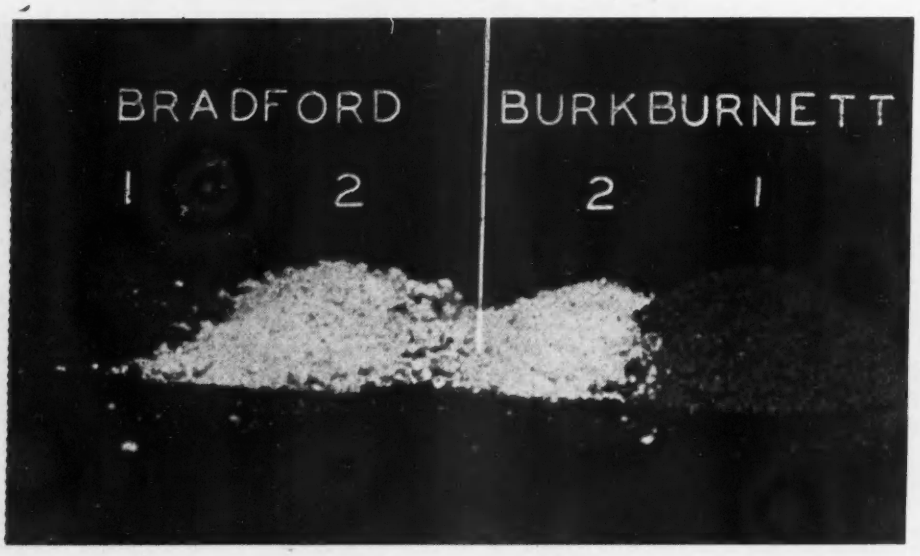

FIGURE 8. Crushed oil sands:
No. 1. Not treated.
No. 2. Treated with strong chromic acid.

ing operation. This is so in practice. In Venango sand, on the other hand, with its predominantly larger pores, its white, inorganic, water-wet, hydrophylic pore surfaces, all attempts at water flooding have failed. The water-wet pore surfaces do not permit oil to completely occupy a pore at any section. Capillary and interfacial forces cause the driving water to preferentially move around existing oil globules through space already occupied by water and hence to move forward with very little or no oil. An air or gas drive, under these circumstances, would tend to keep toward the centers of the pores and drive out some of the oil.

These phenomena would apply equally to natural water- and gas-drive circumstances. If, in addition to the usually determined facts of permeability, porosity and oil and water content, for a particular sand the discussed pore characteristics are determined, the actual mechanics of oil retention and oil removal for that sand are determinable. With this information the reservoir engineer can competently plan the handling of that operation, whether it be natural production, pressure maintenance by gas or water, or secondary recovery by the use of gas, air or water. The result can be that desired by all oil producers: the largest quantity of oil ultimately produced at the lowest unit cost.

Acknowledgments

In the course of carrying on the studies here reported, Dr. P. G. Nutting was freely consulted. His generous donation of time and experience is greatly appreciated. Francis R. Conley not only prepared the wax casts, but developed various ingenious devices necessary to the successful preparation of them. And without the freely extended cooperation of Ryder Scott Company this work would not have been possible. They provided the necessary sand samples of known specification and origin and carried out numerous laboratory and office operations. Hundreds of special permeability determinations alone were necessary. They were made by Ryder Scott Company. Appreciation is extended to the members of that firm for their generous contribution.

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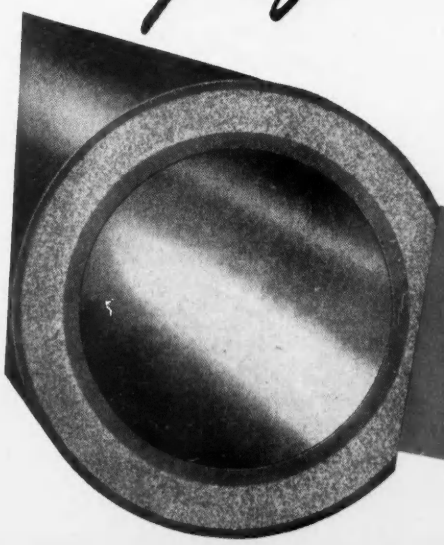

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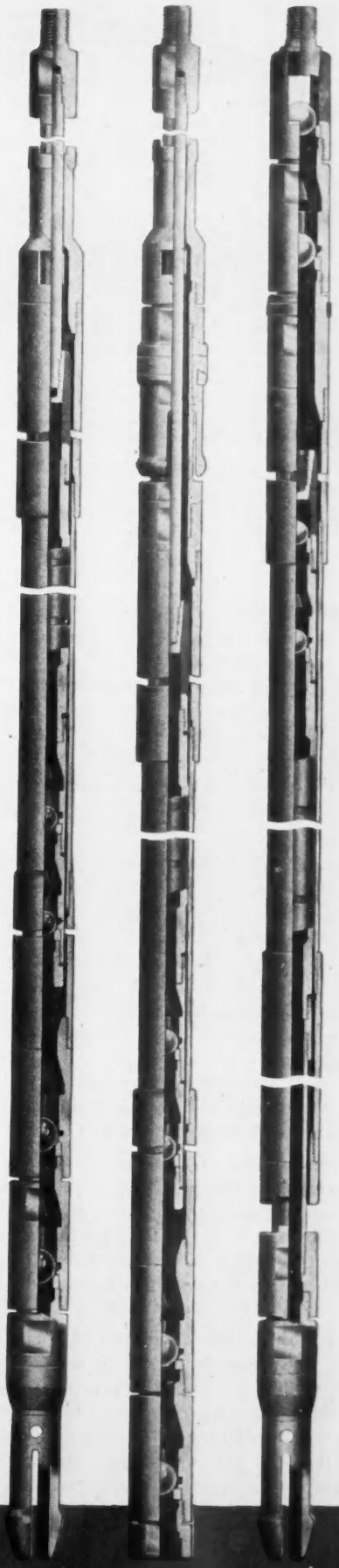

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Water-Flooding Opportunities Explored by Gas Injection

By FREDERICK SQUIRES
Petroleum Engineer, Illinois State Geological Survey

EXPLORING and determining the continuity of sands through the use of high-pressure gas injected through selected wells offers a means for determining relative permeabilities, and also suggests a method for optimum drilling conditions for further development of known shoestring sands. The author demonstrates the technique with maps of water-flood areas, and outlines procedures adaptable for like conditions. This paper is printed by permission of the chief, Illinois State Geological Survey.

IN MANY Illinois oil fields gas-repressuring will be followed by water-flooding. A knowledge of the continuity of the sands and their permeability will be important in choosing areas that are favorable for flooding. The present investigation was undertaken to find methods for obtaining this important information. Gas injection itself proved the best tool.

The relative degree of permeability of the oil sands of a pool is indicated by (1) the initial productions of its wells and (2) the rate of travel of injected gas. The accuracy of the first is limited by the fact that a well's initial production is influenced by the time of drilling in relation to the time of drilling other wells in the same pool. The travel of injected gas is a more reliable measure because the tests may be made simultaneously under the control of the investigator.

The relative permeabilities of the sand between an input well and each of its surrounding output wells may be measured by the time required for injected gas to travel each of the intervening distances and by the volume of gas issuing from each of the output wells.

The direction and extent of permeable areas, and probable producing areas beyond drilled areas, may be indicated by shutting in all the wells, raising the pressure on the whole pool by means of gas injected into the center, and recording the pressure and the rate of pressure decline on each of the shut-in output wells. Wells nearest to undrilled permeable areas will not reach as high pressure and will lose pressure faster than the wells nearer the outer limits of a permeable sand.

The relative permeability of the sands around different input wells may be measured by the difference in the amount of pressure required to inject the same volume of gas into each.

The continuity of a sand may be determined by injecting a tracer gas into an input well and recovering it from output wells.

The foregoing introductory statements are treated more fully in the following text. They are illustrated by a map of Crawford County showing all its repressured areas, a typical repressuring project on which sand permeabilities are measured by forcing gas from input through surrounding output wells; graphs on pressure-volume relationships showing the method of measuring sand permeability around input wells; a table of input wells with the pressures required to inject equal volumes per day as a comparison of permeabilities in different areas; a repressured project on which permeability determinations both by core analyses and input pressure-volume relationships have been made in order to relate the two methods; contours on the same area drawn from pressure-volume relationships; a diagram showing the method of exploration beyond drilled areas; and a diagram illustrating a test for continuity of stratum.

The map of Crawford County (Figure 1) shows the areas of Robinson sand production and marks the parts which have been repressured. The average sand thickness is 20 feet. All the investigations treated in this paper have been confined to this county.

Permeability Measured by Volume of Output Gas

Figure 2 contains contours to show the volumes of injected gas produced simultaneously from output wells. As between wells equidistant from an input well, the permeability of the intervening sand varies directly as the volumes of gas traveling from the input well to each surrounding output well. A closer correspondence between the contours and the variations of permeability would have resulted if each input well had been operated alone, which would have avoided competition with neighboring input wells.

Later in the life of the wells, volumes would increase under the same pressure because the smaller amount of liquid in the sand would increase its permeability to gas. However, sand areas originally more permeable than others would become more so as time passed.

Relative permeabilities of the sand between input and surrounding output wells may be measured by speed of travel of injected gas. When injection is begun on a new operation the time required for injected gas to reach each output well is noted and a map of the area is contoured with lines representing equal time intervals. The resulting picture gives measurements of relative permeabilities.

This may be done at any later time by using a tracer gas, noting the time of

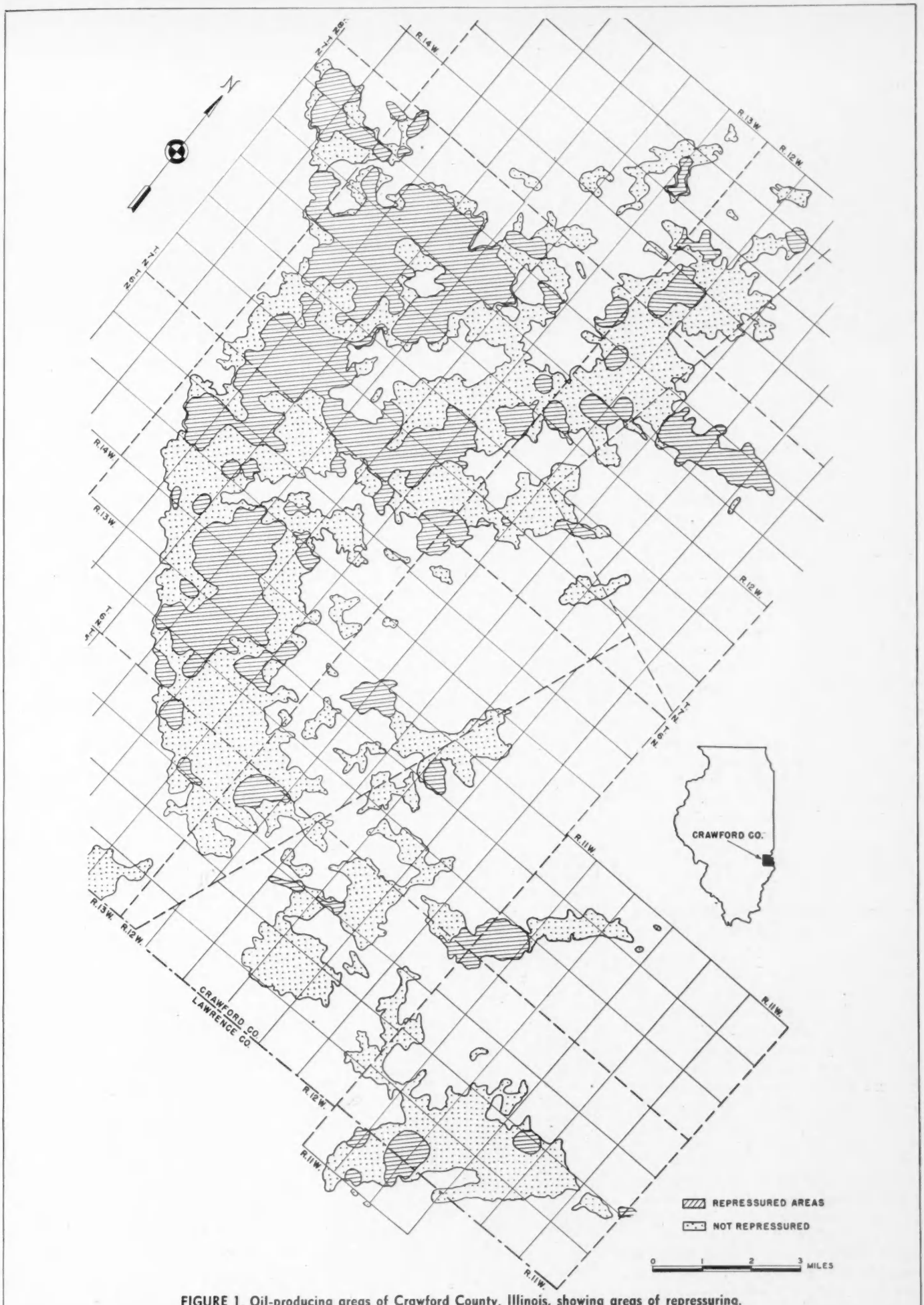


FIGURE 1. Oil-producing areas of Crawford County, Illinois, showing areas of repressuring.

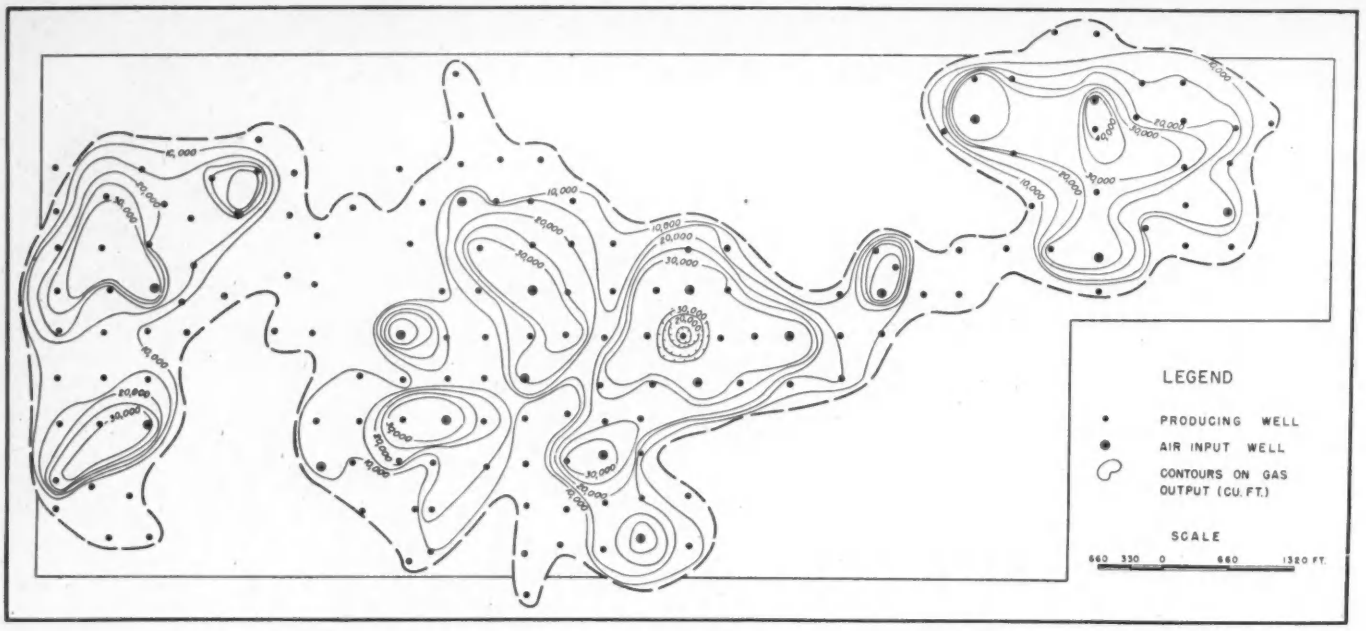


FIGURE 2. A repressured area in Crawford County, Illinois, with contours showing equal volumes of gas output per day.

arrival of the tracer at the output wells, and drawing a contour map as above. Air is a good tracer gas, as are carbon dioxide, helium, and many others.

The tests shown in Figure 2 are suggestions for a method rather than examples of an ideal performance. It is clear that these methods measure the average permeability of the sand body and do not indicate vertical variations in the permeabilities of the sands tested. Such vertical variations may be measured in any input well by filling the sand bore, foot by foot, with a removable seal and measuring the input volumes produced by uniform pressure for each of the diminishing areas of exposed hole. From such records the relative permeability in terms of volume rate of injection of gas may be figured for each foot of sand.

Extent of Permeable Areas Beyond the Drilled Portion

The direction of the extension of permeable and therefore probably productive sand beyond the drilled area may be tested by closing in the casingheads of all output wells, creating a high artificial pressure on the sand through a central input well, and observing the immediate pressure and the rate of pressure decline at each well. The pressure will decline in the direction of the outside areas of permeable sand beacuse the injected gas will escape from the drilled areas into them in an effort to establish equilibrium.

This method was successful in showing the connection between isolated pools in the Cow Run sand in southeastern Ohio. It is most dependable on highly permeable shoestring sands that have little natural rock pressure. The process is noted in Patent 1,168,757, issued to Frederick Squires, by the claim "The method of determining the location and probable direction of extent of gas or oil-bearing strata which consists in sinking three or more wells to such strata at relatively remote points, creating an artificial pressure at one well which shall be observable at the other wells, when the wells communicate with a common stratum, and recording the pressures at all of the wells, whereby the flow of the fluids in the stratum is indicated."

TABLE 1

Pressures Required to Inject 20,000 Cubic Feet Per 24 Hours Into Certain Wells in Crawford County

(In pounds per sq. in.)

Location	PSI	Location	PSI
5-5N-12W...	24.0	10-7N-13W...	22.5
6-5N-12W...	90.0	10-7N-13W...	28.5
6-5N-12W...	42.0	10-7N-13W...	26.5
2-5N-13W...	43.0	10-7N-13W...	24.0
2-5N-13W...	53.5	10-7N-13W...	26.5
16-6N-13W...	17.5	10-7N-13W...	24.0
22-6N-13W...	39.5	10-7N-13W...	15.5
22-6N-13W...	166.0	10-7N-13W...	59.0
22-6N-13W...	84.0	10-7N-13W...	15.0
23-6N-13W...	90.0	10-7N-13W...	21.5
23-6N-13W...	113.0	10-7N-13W...	80.0
23-6N-13W...	76.0	10-7N-13W...	102.5
27-6N-13W...	30.0	10-7N-13W...	19.5
28-7N-12W...	56.0	10-7N-13W...	36.0
34-6N-13W...	20.5	10-7N-13W...	28.0
9-7N-12W...	13.5	10-7N-13W...	50.5
9-7N-12W...	82.0	10-7N-13W...	18.0
9-7N-12W...	95.0	*10-7N-13W...	25.0
9-7N-12W...	210.0	11-7N-13W...	26.0
9-7N-12W...	260.0	16-7N-13W...	72.0
9-7N-12W...	245.0	16-7N-13W...	172.0
9-7N-12W...	86.0	18-7N-13W...	34.0
9-7N-12W...	155.0	18-7N-13W...	23.0
10-7N-12W...	113.0	18-7N-13W...	67.0
10-7N-12W...	116.0	19-7N-13W...	84.0
10-7N-12W...	110.0	19-7N-13W...	74.0
11-7N-12W...	21.0	20-7N-13W...	99.0
11-7N-12W...	193.0	20-7N-13W...	74.0
18-7N-12W...	28.5	21-7N-13W...	55.5
8-7N-13W...	200.0	21-7N-13W...	60 0
8-7N-13W...	112.0	24-7N-13W...	34.0
8-7N-13W...	160.0	24-7N-13W...	19.5
9-7N-13W...	26.0	29-7N-13W...	140.0
9-7N-13W...	38.0	30-7N-13W...	92.0
10-7N-13W...	13.0	11-7N-14W...	75.0
10-7N-13W...	19.5	12-7N-14W...	64.0

* Core analysis on this well gave an average permeability of 165 M.D.

The pressures imposed on input wells and the volumes of gas injected at these pressures have been recorded at regular intervals on many repressured properties. The pressure and corresponding volume input rate for each well usually changes, due in some cases to the fact that the operator begins with low pressures in order to avoid the danger of bypassing and later increases the pressures as he becomes more familiar with the characteristics of his property. The pressures and corresponding volume input rates for a single well may be plotted on a graph. If log-log graph paper is used the points generally fall into a straight line pattern which may be easily extrapolated (Figure 3).

In order to compare permeabilities in different wells it is necessary to determine for each well either the pressure required to inject gas at a standard rate or the rate of gas injection at a standard pressure. Of these two possible methods the first was chosen as the more convenient. A standard input rate of 20,000 cubic feet of gas per day was selected and the pressure necessary for this input for each well was determined from the graphs.

It will be understood that this method gives general and not accurate, specific information. It is believed, however, that its application will be useful in dividing repressured areas into permeability classifications which will answer some of the questions which will arise in the minds of operators looking for floodable territory. Such information may then be supplemented by coring and core analysis.

Very few core analyses are available for Crawford County but three of these

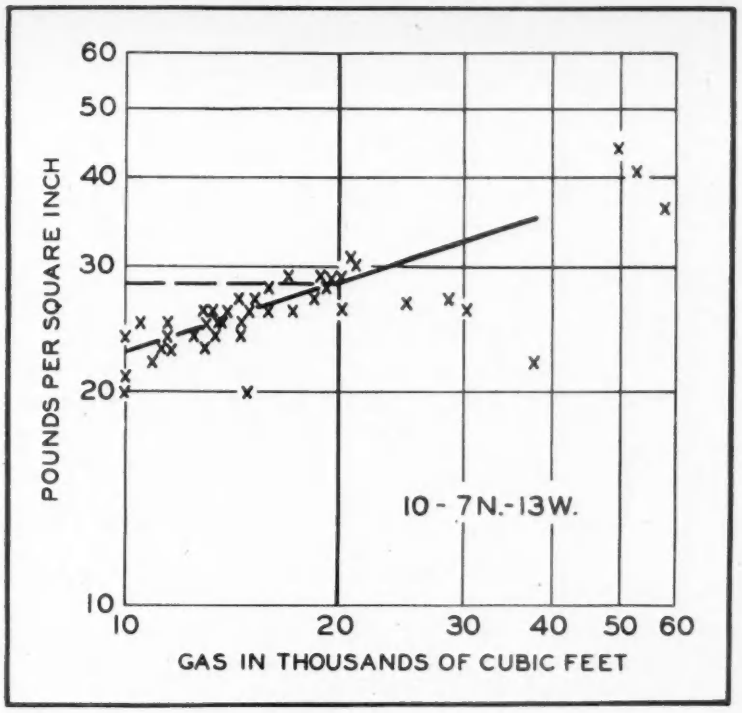


FIGURE 3. Graph of a set of observations on a single well, showing rate of gas intake in thousands of cubic feet per day for various pressures.

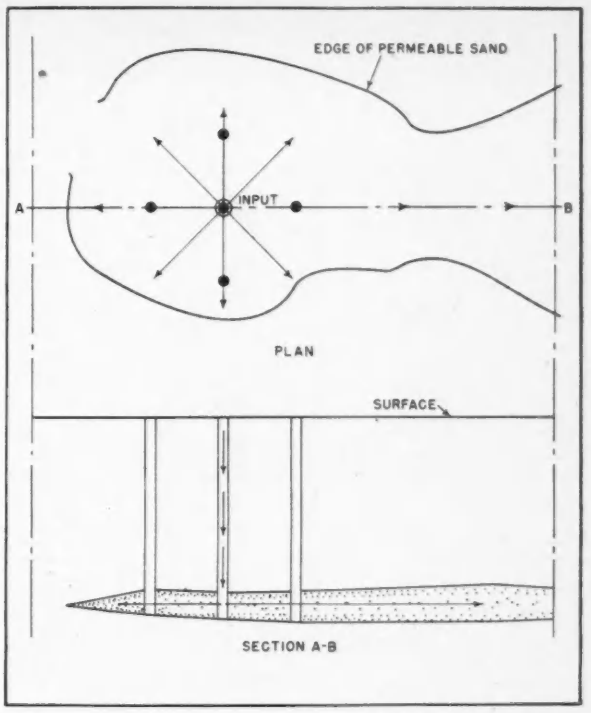


FIGURE 5. Test for permeable sand beyond drilled area.

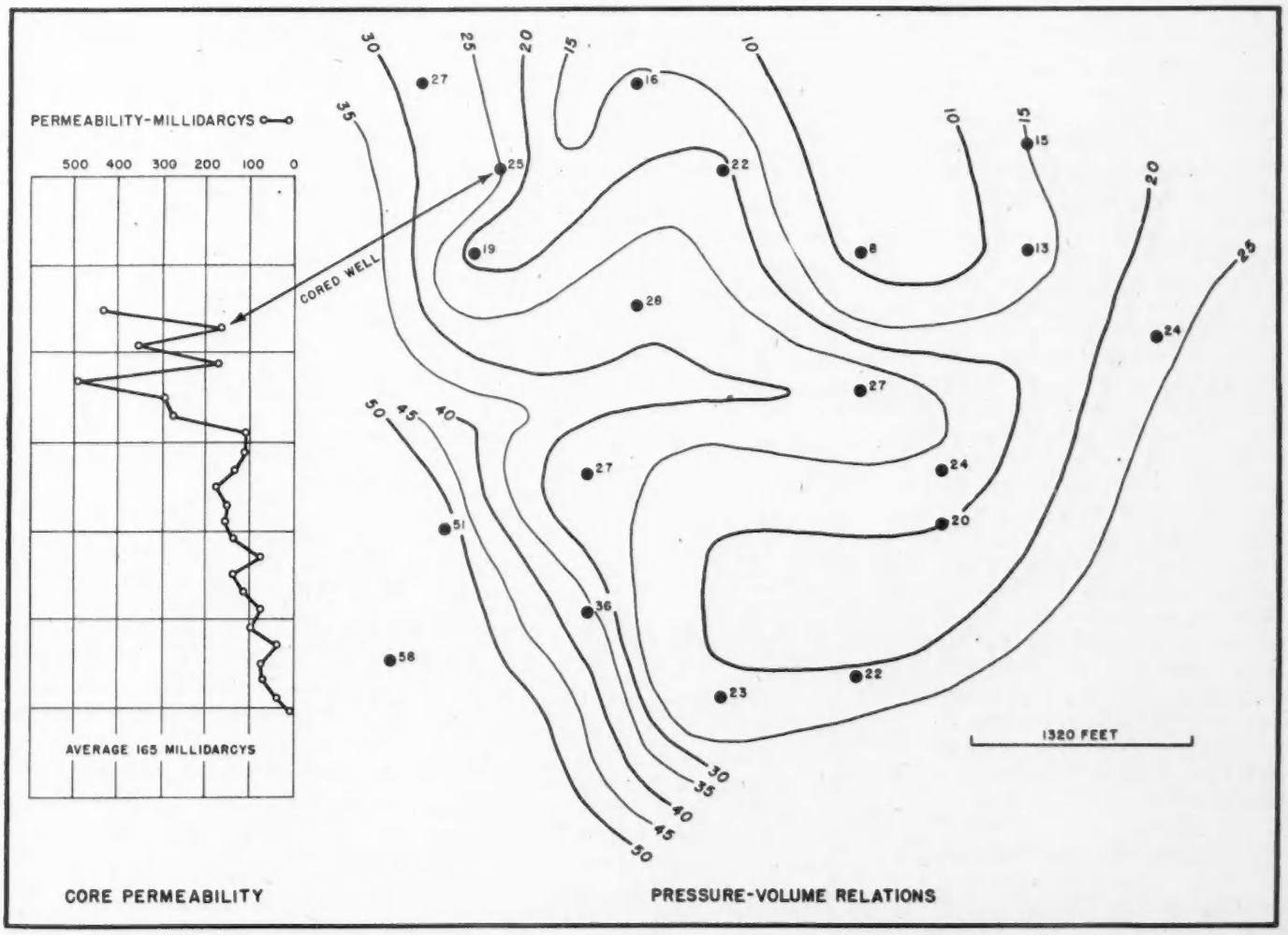


FIGURE 4. A repressured area in Crawford County, Illinois, with contours showing equal pressures in pounds per square inch required to inject gas at a standard rate of 20,000 cubic feet per day as determined from graphs like that shown in Figure 3.

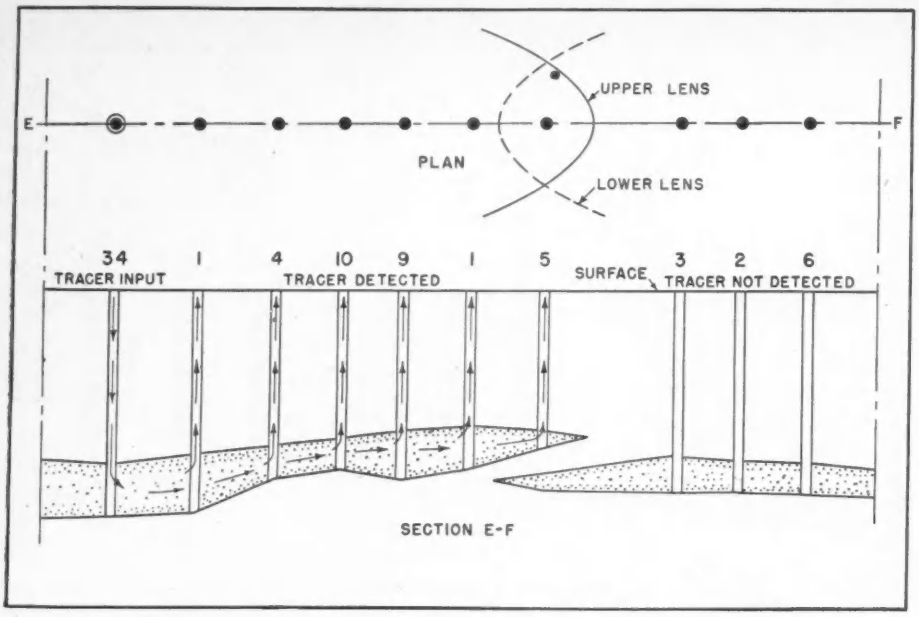


FIGURE 6. Use of tracer in gas to detect discontinuity of sand.

are from an area on which there are records of pressure-volume relationships for a large number of input wells. It is therefore possible to compare these two methods of measurement and to relate the results to other territory on which there are only pressure-volume records.

One core analysis was made for a well drilled to serve as an input. The analysis shows an average permeability of 165 millidarcys. The results of this analysis are shown in Figure 4. Afterward this well took 20,000 cubic feet of gas per day at a pressure of 25 pounds per square inch.

All the input wells in the immediate vicinity were graphed for pressure-volume relationship. The pressures found were set down on a map (Figure 4) and contours showing equal pressures were drawn. The result shows an interesting gradation of permeability from high at the northeast to low at the southwest.

As a cored well with an average permeability of 165 millidarcys required a pressure of 25 pounds per square inch to inject 20,000 cubic feet of gas per 24 hours, it is fair to assume that input wells which required higher pressures were in less permeable sand than an average of 165 millidarcys, and that wells which required lower pressures for an equal input rate were in more permeable sand than the well in question.

Since this is true in the area contoured it is equally true in other parts of Crawford County.

Permeabilities by Pressure for Different Areas

Table 1 shows the pressures required to inject 20,000 cubic feet of gas per day in the input wells listed. From it the general degree of permeability of the sand at the input well may be inferred. Only a few of the many Crawford County input wells are used. The investigation could be extended to cover the whole territory. It will be useful in getting general ideas about well spacing and required water pressures for flooding when studied by contours, as shown in Figure 4. Such widespread permeability studies may throw some light on sedimentation.

Exploration Beyond Drilled Areas

Some of the shoestring sands in southeastern Ohio are narrow and winding, as though laid down in ancient river beds. Oil was first found in isolated areas but later the areas were connected by drilling. The winding nature of the productive area and the extremely narrow connecting links between wider pools resulted in drilling many dry holes.

In several areas the practice of exploring with gas injection suggested the direction in which to extend the pools in order to connect them up to other pools with fewer dry holes. The practice is illustrated in Figure 5, which shows a diagrammatic layout of five wells, the central one of which is an input well and the others normally output wells. The process of exploring with injected gas consists of shutting in all the output wells, raising the pressure on the area through injection of gas at the input, reading the pressure on all the wells immediately and then at regular intervals thereafter. If the shoestring sand extends beyond the drilled area it will bleed off the gas and thereby lower the pressure most at the well nearest to the extension. New drilling is indicated in the direction beyond the well that shows the least original pressure and the fastest drop in pressure. Where production was found by this means the new wells showed that the sand had been invaded by the gas; it was shown by their initial production, by tendency for oil to rise in the hole, and by the large volume of gas produced with the oil.

Conditions like those presented by the Cow Run sand in southeastern Ohio are well adapted for such exploration. The fact that the sand lenses out at the sides, that it is highly permeable, has little or no rock pressure, and exists in narrow continuous winding bodies, all simplify the use of injected gas for the purpose. The method may be applied in other fields.

Test for Sand Continuity by Tracer Injection and Recovery

The water-flood operator must be sure the sands are continuous over the areas he intends to flood. This is easily tested in gas injection territory. Sand must extend from well to well if gas has traveled between them. If there is any doubt as to whether the gas issuing from a well is native to the formation or is injected gas, there are many tests to remove the doubt. Tracers may be used in the injected gas and detected at the output wells when input and output wells are in a continuous stratum. Their presence in output gas is a sure evidence of throughput. Air is a good tracer because output gas containing air may be checked for oxygen with an Orsat equipment. Carbon dioxide is another test gas, and there are many more.

Figure 6 shows a condition that is fatal for flooding, but one that can be easily detected in advance by injecting tracer gas.

Summary

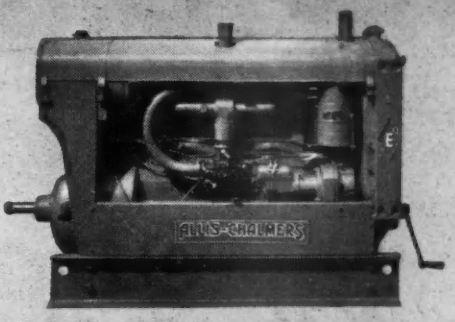
The methods described may be used by the water-flood operator to gain a general knowledge of sand permeabilities in gas injection territory. What the methods lack in exactness they make up for in the vastness of the areas they are able to cover.

This is only a beginning. It is hoped that others will give expert thought to perfect the methods here suggested until they provide a more exact relationship between sand permeabilities derived from gas injection and sand permeabilities established by core analyses, and that they will develop a method by which permeabilties found by injected gas may be translated into permeabilities to be encountered in water injection.

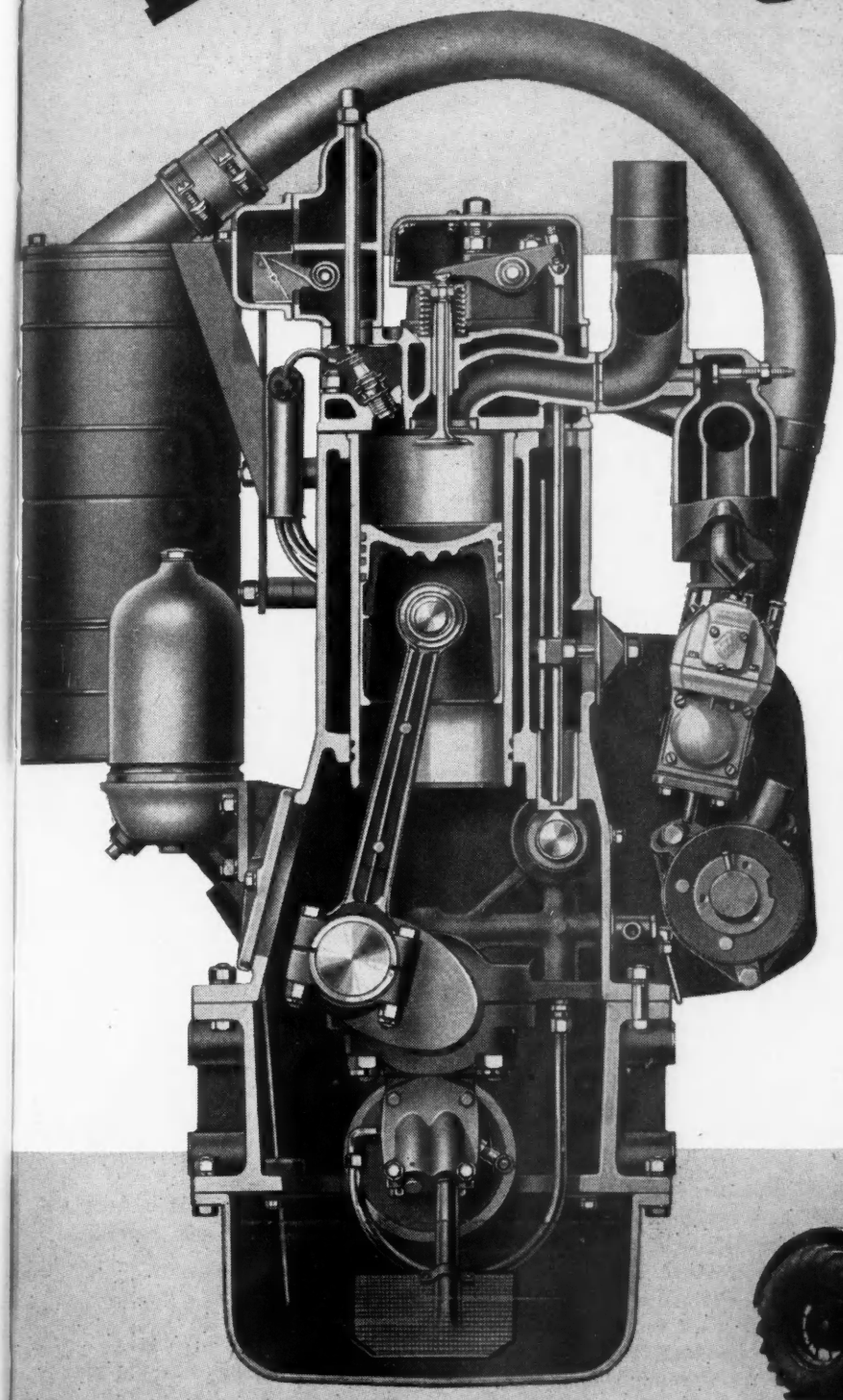
ACKNOWLEDGMENTS

The writer wishes to thank Parke A. Dickey, Kurt H. Andresen, A. J. Rosenlieb, Millard Flood, William S. Corwin, Robert A. Wilson, A. H. Bell, Paul G. Luckhardt, and J. S. Machin for help on this problem.

Lubrication *in*



POWER UNITS o
PULLING UNITS



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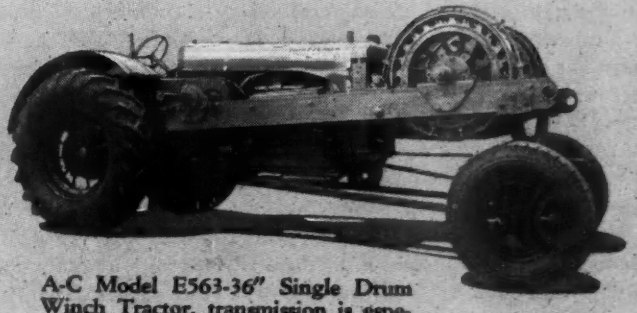

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Methods of *Paraffin* Removal

INVESTIGATION of results obtained in removing paraffin from wells in the Appalachian area through various methods brings out pertinent data which bear on problems of clearing marginal production wells of this down-the-hole choke in other areas. The report is based upon that section of Report of Investigations Number 4193 of the Bureau of Mines which deals with paraffin removal, and is substantially as presented there.

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PARAFFIN is the term given waxy residues from crude oils that are deposited in the tubing, casing, and on the walls of the producing well bore. The oil produced in the Appalachian region has a high wax content, and paraffin deposits have always presented an operating problem. During the period of flush production, paraffin deposits were especially troublesome in the tubing, casing and lead lines, but as the reservoir pressure and the rate of gas production decreased, the removal of paraffin that was deposited on the producing sand face and in the pores of the sand immediately around the well became the operator's most serious problem.

C. E. Reistle,[1] in describing the nature of paraffin deposits and the conditions responsible for them, reports that the most important factor is temperature, as the quantity of paraffin that crude can hold in solution decreases as the temperature of the oil is lowered. Paraffin also is more soluble in the lighter fractions of a crude than in the heavier fractions, so that any "stripping" of a crude (loss of the more volatile components of a crude by evaporation) decreases the amount of paraffin which the crude can hold in solution.

The upper chart of Figure 1 shows the effect of temperature upon the solubility of crude paraffin from the Salt Creek, Wyoming, field in 81-gravity API gasoline, 39 crude oil, and 29 mineral oil. The increasing solubility of the crude paraffin at two temperatures in the higher specific gravity fractions of a crude is shown in the lower chart of the same figure.

The cooling effect produced by the expansion of gas during the production of oil accounts for the deposition of paraffin in the pores of the sand immediately around the producing well and on the exposed face of the producing sand in the older wells, because it is here that the greatest pressure drop and consequently the maximum cooling occurs. This is particularly true of wells producing large volumes of gas at high gas/oil ratios, as the greater proportion and rate of gas production increases the cooling of the produced oil.

That the quantity of light hydrocarbons (gasoline through kerosine fractions) in a crude affects the deposition of paraffin in wells is evident from the fact that the crudes containing less than 50 percent light fractions produced from some sands (such as the Maxton and Gordon) deposit paraffin in troublesome quantity, whereas a negligible amount of paraffin may be deposited in wells producing high gravity crudes. Evaporation of the lighter hydrocarbons in crudes is also responsible for the increase in paraffin trouble experienced when pumping wells under vacuum[2].

Little or no paraffin is said to accumulate in wells that produce appreciable quantities of water with the oil, because the water has twice the specific heat of oil and retains enough heat to keep the cooling action of the expanding gas to a minimum. The washing effect of water on the sand face is also helpful in preventing the formation of paraffin deposits in wells.

Horne,[3] Reistle,[4] and Mills,[5] show that crude contains, in solution, a series of paraffin waxes and gums. If these wax and gum compounds were individually separated out of the oil, their separate melting points would range from below 0° F. to above 200° F. All the paraffins are crystalline, but they are commonly segregated into two groups, the "crystalline" and "microcrystalline" or "amorphous." The crystalline paraffins have melting points ranging up to 150° F. The microcrystalline waxes melt at 150° to 200° F. These paraffins dissolve each other to some extent,[6] and in a large volume of the base oil the entire series of paraffins will dissolve and liquefy at about 130° F. The crude wax deposited in the well is composed chiefly of the higher melting point waxes, as is indicated by the analysis given in Table 1 of a rod wax from a well producing from the Big Injun sand in Clay County, West Virginia. The mutual solubility of wax fractions in the Clay County oil is evident from the analysis, in which it is shown that the melting point of the crude wax was 161.9° F., although only three fractions, comprising 10.1 percent of the oil-free wax, had lower melting points.

Apparent melting points have been determined for the following paraffin samples:

State	County	Township	Prod. Sand	Apparent Melting Point, °F.
Ohio	Washington	?	Macksburg Stray	135
Ohio	Perry	Thorne	Clinton	152
W. Va.	Mannington	Marion	Maxton	136
W. Va.	Clay	Monongalia	Big Injun	143
W. Va.	Batelle	Monongalia	Gordon	102
W. Va.	Clay	Monongalia	Fourth	138
W. Va.	Mannington	Marion	Fifth	117

Solvents for Removing Paraffin

The oil-well reconditioning jobs studied indicate that the only solvents used

for paraffin removal in the Appalachian area are gasoline and crude oil. The generally preferred solvent, it has been found, is natural or drip gasoline mixed with an equal volume of crude oil. When gasoline is used as a solvent in straight cleanout work, the shot hole is filled with gasoline or a crude oil-gasoline mixture. The solvent is agitated for several hours by running the tools, with either a special agitator or regular pattern jars, and then bailed from the well. If the oil is run to the stock tanks, it will have to be weathered several days to evaporate the light fractions before most pipe line companies will purchase it.

Wells may be treated with hydrocarbon solvents without using cleanout tools to remove superficial deposits of wax from the casing or tubing. To do so, a barrel or two of gasoline is poured into the casinghead of a pumping well, and the lead line of the well is connected to discharge into the casing. The gasoline-crude mixture is circulated for several hours by pumping the well. Then the pump is shut down and the well allowed to stand overnight. The next day the solvent is again circulated in the well for a few hours before the lead line is reconnected to storage tanks and the oil and solvent pumped out of the well. This is not considered as effective in cleaning paraffin from the producing sand face as methods to be described later.

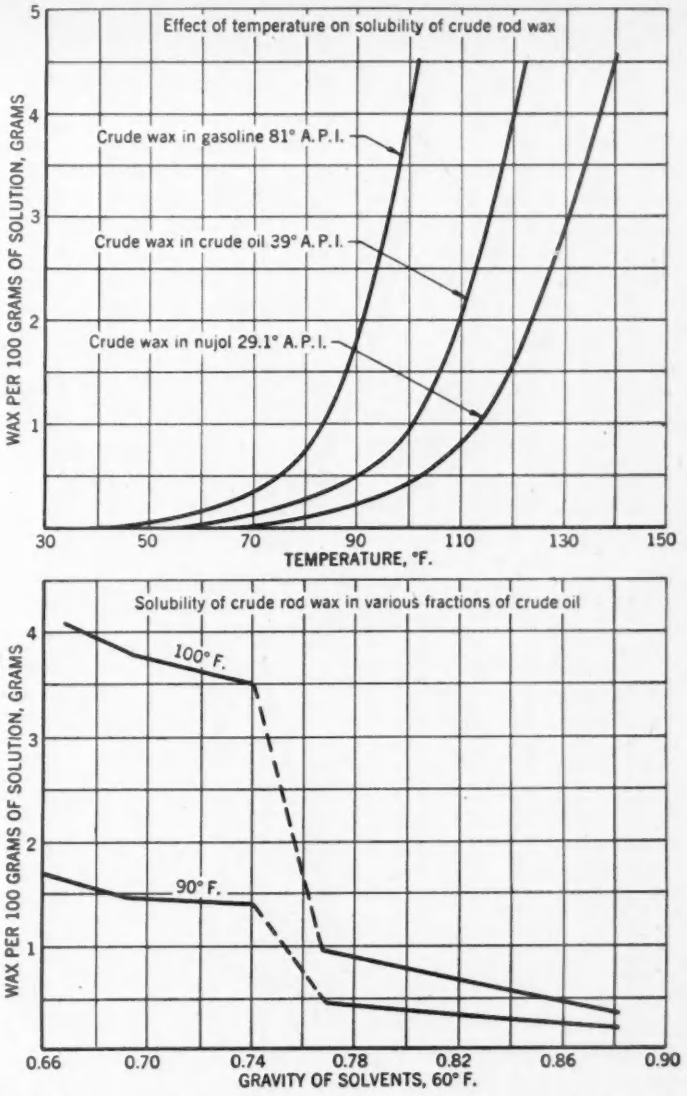
Effect of temperature on solubility of crude rod wax
Crude wax in gasoline 81° A.P.I.
Crude wax in crude oil 39° A.P.I.
Crude wax in nujol 29.1° A.P.I.
WAX PER 100 GRAMS OF SOLUTION, GRAMS
TEMPERATURE, °F.
Solubility of crude rod wax in various fractions of crude oil
100° F.
90° F.
WAX PER 100 GRAMS OF SOLUTION, GRAMS
GRAVITY OF SOLVENTS, 60° F.

FIGURE 1. Solubility of crude rod wax from the Salt Creek field, Wyoming. (After Reistle.)

Heated Solvents

As previously mentioned, the solubility of paraffin in gasoline, naphtha, kerosine, gasoil, and crude oil increases as the temperature is increased. In considering methods of using heat to remove paraffin deposits, it is important to know the approximate temperature of the oil in the reservoir. The depth-temperature relationships for Appalachian wells are reported by Tignor,[7] who shows that the average temperatures of West Virginia oil reservoirs are 76° F. at a depth of 2000 feet, 82.5 at 2500 feet, and 90 at 3000 feet. The lower chart of Figure 1 shows that twice as much paraffin will be dissolved by kerosine (sp. gr. 780) at 100° F. as will be dissolved at 90° F., so that the advantage of heating solvents that are used to remove paraffin from sands cannot be questioned. Usually, if the lighter fractions of crude are used as solvents in a well and their temperature is maintained at 130 to 150° F., they they will effectively remove paraffin from the sand face and well bore. To remove paraffin that has deposited in the sand about a well, temperatures higher than 150° F. and probably as high as 200° F. must be maintained in the well for several hours to allow the sand face to reach a temperature above the melting point of the paraffin.

Electrical Heating

Bottom-hole electrical heaters are sometimes used to heat solvent in the shot holes of wells in order to remove paraffin from the sand face and from the pores of the sand around the well.[8, 9, 10, 11] Two types of electrical heaters have been used in the past few years for this purpose in wells in this area. Data were obtained in four wells in which a resistance-type heating unit supplied with electricity from a portable truck-mounted generating unit was used in the well. The heating unit is patented, and no details of its construction and operation are available other than that the unit is insulated and can be used in oil or water. All four wells were treated between June 16 and November 19, 1939, by pulling tubing, electrically heating the liquid in the shot hole, rerunning tubing and rods, and pumping off the well. Cleanout tools were not used on the jobs. While the wells were being heated, temperatures of the fluid in the well were reported to be as high as 180° F., but the length of time these temperatures were maintained is not known. Total oil production of the lease for the first six months of 1939 was only 30 barrels, but during the last six months of the year, after the wells had been treated, the lease produced 260 barrels of oil, a net increase of 230 barrels, which is attributed to heat-treating the four wells.

During cleanout work on Wells A-65, F-1 and F-5, they were electrically heat-treated to remove paraffin from the sand face. The production curves in Figure 2 show the effect of cleaning and heating upon the wells' oil production rates. The heater was operated continuously for 40 hours in Wells A-65 and F-1, but unfortunately the temperature of the well fluid after heating was not measured in either well. The length of time the heater was operated in Well F-5 was not recorded but, after heating, the temperature of the liquid in the well was reported at 80° F. Well F-1 repaid the cost of heating in 207 days, but neither of the

other two jobs repaid the cost of cleaning out during the period for which the production figures were plotted.

Heater

The heater used was a resistance unit mounted in a seven-foot section of perforated four-inch pipe, which is lowered into the well on a 5/16-inch steel cable from a multi-drum reel mounted on a truck. An insulated, single-conductor copper cable is wound on the second drum of the reel; the copper cable is the positive lead to the heater, the steel cable being used as the negative lead. A 250-volt, 70-ampere, gasoline-engine-driven generator mounted on the truck furnishes power to the heater.

When the heater is to be used in a well, the well first should be cleaned to bottom, the sand face washed down, and the well bailed. As the heating unit is not insulated, the heater must be submarged in oil in the well to operate successfully. Recommended duration of the heating is 40 hours, with the generator operating at capacity. In 1943 a charge of $4 per hour, in addition to mileage fees, was being made by the service company for operating the unit.

At present, bottom-hole electrical heating is not widely used in the Appalachian area, and other methods of removing paraffin are considered cheaper. However, with improved apparatus and a well-organized service area, so that the equipment can be in use most of the time, the per-well costs of electrical treating probably can be reduced sufficiently to provide a cheap and effective method for removing paraffin from wells.

The Mosser Heater

An ingenious method of heating liquids in oil wells was developed in 1943 to offset the critical shortage of boilers during the war, which was hindering a program of steaming oil wells to remove paraffin during cleanout work. The Mosser[12] heater has been used in several wells 1800 to 3100 feet deep. A burner made from a perforated swage is screwed to the bottom joint of the tubing string and is suspended in the well several feet below the top of the producing sand. The shot hole is filled with water, oil or other solvent that is to be heated, and combustible air-gasoline mixture, compressed at the surface, forced down the tubing under enough pressure to displace all liquid from the heater. The mixture then is ignited at the burner by dropping into the tubing a specially-made nipple containing a firing mechanism and a railroad fuse, which is ignited by a shotgun shell when the nipple strikes the baffle at the bottom of the burner. The portable gasoline-engine-driven compressor that furnishes the air-gasoline vapor mixture to the burner was built from an automobile engine by installing feather valves and removing the ignition system. The automobile carburetion system was retained on the compressor unit to vaporize the gasoline and mix the air-gasoline vapor which is burned in the shot hole. The quantity of gasoline consumed by the burner averages from five to seven gallons per hour. The compression of a mixture of gasoline vapor and air is hazardous, and extreme precautions should be taken to prevent an ex-

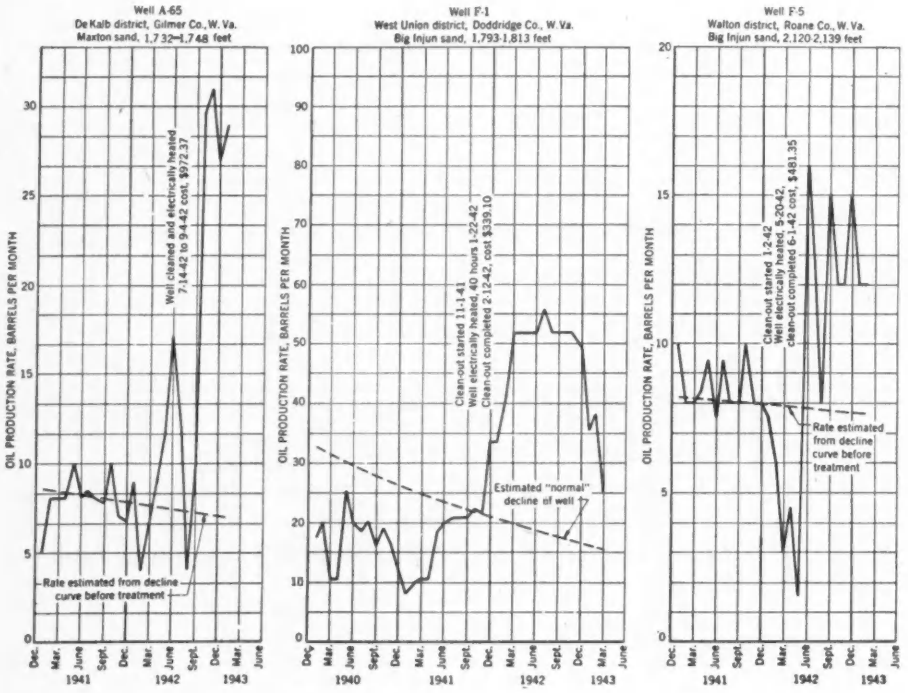
Well A-65
De Kalb district, Gilmer Co., W. Va.
Maxton sand, 1,732–1,748 feet
Well cleaned and electrically heated 7-14-42 to 9-4-42 cost, $972.37
Rate estimated from decline curve before treatment
Well F-1
West Union district, Doddridge Co., W. Va.
Big Injun sand, 1,793-1,813 feet
Clean-out started 11-1-41
Well electrically heated, 40 hours 1-22-42
Clean-out completed 2-12-42, cost $339.10
Estimated "normal" decline of well
Well F-5
Walton district, Roane Co., W. Va.
Big Injun sand, 2,120-2,139 feet
Clean-out started 1-2-42
Well electrically heated, 5-20-42,
clean-out completed 6-1-42 cost, $481.35
Rate estimated from decline curve before treatment
OIL PRODUCTION RATE, BARRELS PER MONTH
1941
1942
1943
1940

FIGURE 2. Curves showing the effect of electrical heat treatments on the oil-production rates of three wells.

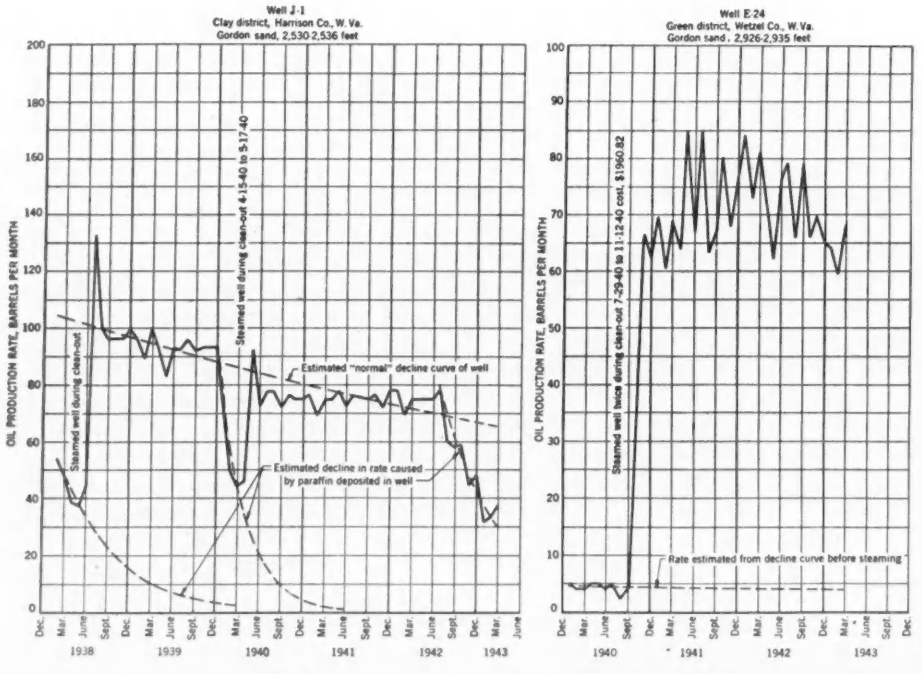
Well J-1
Clay district, Harrison Co., W. Va.
Gordon sand, 2,530-2,536 feet
Steamed well during clean-out
Steamed well during clean-out 4-15-40 to 5-17-40
Estimated "normal" decline curve of well
Estimated decline in rate caused by paraffin deposited in well
Well E-24
Green district, Wetzel Co., W. Va.
Gordon sand, 2,926-2,935 feet
Steamed well twice during clean-out 7-29-40 to 11-12-40 cost, $1960.82
Rate estimated from decline curve before steaming
OIL PRODUCTION RATE, BARRELS PER MONTH
1938
1939
1940
1941
1942
1943

FIGURE 3. Curves showing the results of steaming wells.

plosion or fire in the compressor or piping.

Partial records are available on seven wells treated by the Mosser heater. Three of the wells were treated by filling the shot hole with water and operating the heater for five hours. After heating, temperature of the water in the wells ranged from 170° F. to 210° F. In all the wells the temperature of the heated liquid in the shot hole was above the melting point of the paraffin.

Steaming to Remove Paraffin

At the time most of the oil fields in the Appalachian region were developed, steam was universally used as a source of power for drilling and pumping, and the injection of steam into wells to remove paraffin deposits from the well bore was commonly practiced. As gas engines have replaced steam-driven machinery, boilers are no longer a common part of lease equipment, but "steaming" has continued to be the most widely used method of cleaning paraffin from wells. At present this is accomplished by injecting steam generated by small portable boilers into the wells through tubing and the technique has been frequently described.[13, 14, 15, 16]

METHODS OF STEAMING WELLS: The boilers range in size from ten to 35 horsepower, and where gas is not available, coal or wood is used for fuel. Most operators use 15- to 25-horsepower upright boilers, because they can be moved easily from one well to another. Some type of superheater should be used with small boilers to insure maximum rise in temperature of the liquid in the wells. Crumley[14] describes a simple, effective, gas-fired superheater that is nothing more than a coil made of three joints of two-inch tubing installed in a joint of 6⅝-inch pipe. When a well is to be steamed, the boiler is placed as close to the well as is safe, gas and feedwater lines are connected, and a one- or two-inch steam line with a full swing at the wellhead is connected to the tubing, to direct the stem down the well. Wells in which the casing is set on a packer instead of a shoulder should not be steamed, because the expansion of the casing during steaming will wreck the packer.

Well "Washed Down"

When the steaming operation is part of a cleanout job, the well first is cleaned to bottom and "washed down."

After the well has been bailed down, common practice is to run tubing with a working barrel from which the standing valve has been removed. A perforated anchor below the working barrel is placed opposite the sand; the tubing then is raised to allow for 2½ inches of expansion for each 100 feet of tubing in the well. With the boiler operating at capacity, steam is admitted to the tubing and throttled at the wellhead to maintain a working pressure of 100 to 125

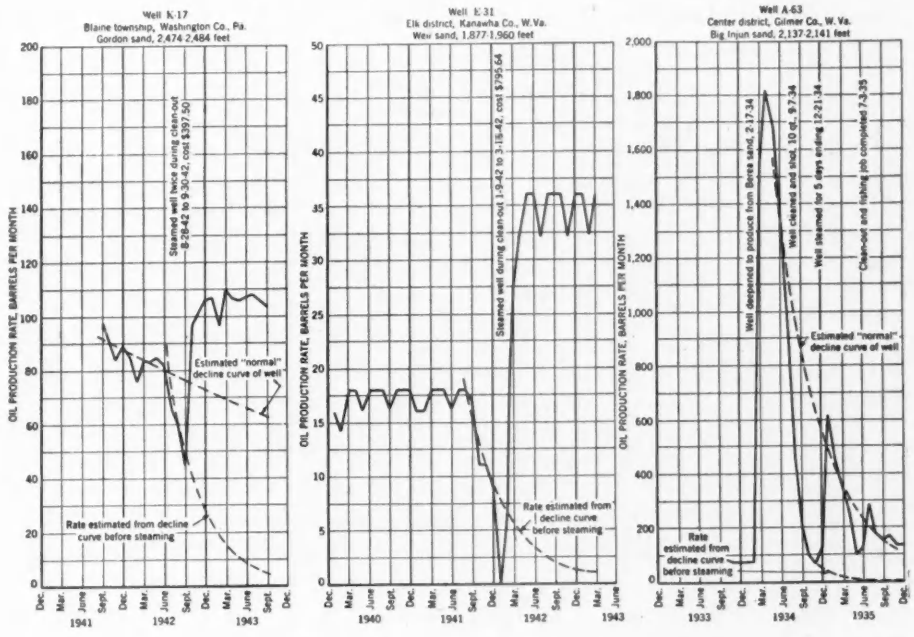
Well K-17
Blaine township, Washington Co., Pa.
Gordon sand, 2,474-2,484 feet
Steamed well twice during clean-out 8-28-42 to 9-30-42, cost $397.50
Estimated "normal" decline curve of well
Rate estimated from decline curve before steaming
OIL PRODUCTION RATE, BARRELS PER MONTH
Well E-31
Elk district, Kanawha Co., W.Va.
Wew sand, 1,877-1,960 feet
Steamed well during clean-out, 1-9-42 to 3-18-42, cost $795.64
Rate estimated from decline curve before steaming
Well A-63
Center district, Gilmer Co., W.Va.
Big Injun sand, 2,137-2,141 feet
Well deepened to produce from Berea sand, 2-17-34
Well cleaned and shot, 10 qts., 9-7-34
Well steamed for 5 days ending 12-21-34
Clean-out and fishing job completed 7-3-35
Estimated "normal" decline curve of well
Rate estimated from decline curve before steaming
1941
1942
1943
1940
1933
1934
1935

FIGURE 4. Curves showing the results of steaming wells.

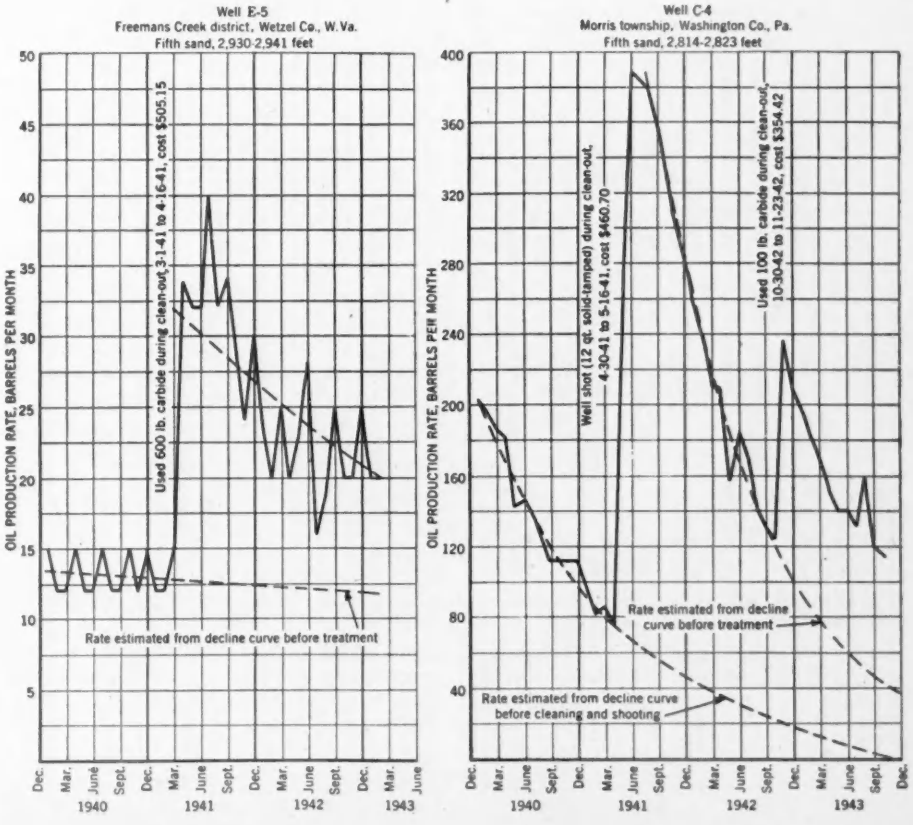
Well E-5
Freemans Creek district, Wetzel Co., W.Va.
Fifth sand, 2,930-2,941 feet
Used 600 lb. carbide during clean-out, 3-1-41 to 4-16-41, cost $505.15
Rate estimated from decline curve before treatment
OIL PRODUCTION RATE, BARRELS PER MONTH
Well C-4
Morris township, Washington Co., Pa.
Fifth sand, 2,814-2,823 feet
Well shot (12 qt. solid-tamped) during clean-out, 4-30-41 to 5-16-41, cost $460.70
Used 100 lb. carbide during clean-out, 10-30-42 to 11-23-42, cost $354.42
Rate estimated from decline curve before treatment
Rate estimated from decline curve before cleaning and shooting
1940
1941
1942
1943

FIGURE 5. Curves showing the results of using calcium carbide in two wells.

pounds per square inch on the boiler. Steaming is continued until the manometer of an orifice tester connected into the casinghead begins to fluctuate, indicating that the liquid in the well is above the top of the sand. If steaming continues after the shot hole is full of liquid, the hot water may cause an undue amount of caving of the open hole above the sand.

After shutting off the flow of steam into the well, the standing valve of the working barrel is run in on the pump plunger and the well is pumped off. If the quantity of paraffin recovered by pumping is large, the rods and standing valve may have to be pulled and the well steamed again. After the last steaming, the tubing is pulled and stacked and the well is cleaned out with tools.

Liquefying Paraffin

Some operators prefer to let the hot liquid remain in the shot hole of the well for as long as 24 hours in order to liquefy paraffin that has accumulated in the pores of the sand. Crumley[14] measured the temperature of the liquid in a well daily for seven days after steaming, and found it to be: 198, 183, 165, 148, 129, 108, and 87° F., indicating that the temperature 48 hours after steaming was 183° F., which is high enough to keep any paraffin present in the liquid in a melting state. At lower temperatures, however, the paraffin will solidify and deposit on the sand face if not removed from the well. King[15] reports that when using a 15-horsepower boiler with a superheater delivering steam to the well at 500 to 600° F., the average bottom-hole liquid temperature increased after eight hours' steaming about 167° F., declining to 123° F. after standing 16 hours.

Temperature Data

Temperature data collected during this study include some 30 measurements of the well-fluid temperature after steaming wells for various periods of time. These temperatures range from 116 to 210° F., and there is no noticeable relationship between temperature and depth of wells or between temperature and length of time a well was steamed. Obviously, the final temperature of the condensed liquid in the shot hole of a well varies directly with the total quantity of steam injected into a well, the initial pressure and temperature of the steam, and the rate at which it is injected, and inversely with the heat lost to the well bore above the sand. Because hot water does not dissolve paraffin, the temperature of the condensed water in the shot hole after steaming must be above the melting point of the deposited paraffin, and the mixture of water, paraffin and oil must be pumped or bailed from the hole before it cools sufficiently for the paraffin to solidify again.

In the method of steaming through tubing described by Crumley,[14] the capped anchor joint at the bottom of the tubing string is perforated with the correct number and sizes of orifices to hold a 125-pound per square inch working pressure on the boiler with no valve or other restriction in the steam line leading from the boiler to the tubing. The perforations are drilled in a line along one side of the tubing, and are so spaced that they will be opposite a maximum thickness of pay sand. The tubing is suspended in the well from a ball-bearing trunnion on the casinghead and connected to the steam line by a swivel joint in order that the tubing may be rotated during steaming. By slowly rotating the tubing, wet steam or hot water is jetted against all parts of the sand face. By previously placing a concentrated cleaning compound in the shot hole or adding it in more dilute form to the flowing steam at the wellhead, this hydraulic washing might be aided.

Another Method

Another method of steaming to remove paraffin from wells is to introduce steam through a string of one-inch tubing run into the well along the side of the regular two-inch tubing so as to allow the well to be pumped while steaming is in progress. The two-inch tubing must have a flood nipple below the working barrel, so that the level of the liquid in the well can be maintained at the top of the sand. As in all steaming methods, allowance must be made in spacing the tubing to allow for its linear expansion when heated, and the pump cups should be able to withstand 200° F. Because the small string must be run alongside the two-inch tubing, collars on both strings are bevelled, so that the collars will pass without hanging up. The lower end of the steaming string is perforated over a distance equal to the thickness of the pay sand. Steam is introduced into the well through the one-inch tubing for about three hours, or until the level of the water reaches the flood nipple. The well is then pumped slowly while steaming continues. Steaming is stopped only when the liquid pumped from the well is free from melted paraffin. Operators report that as much as six barrels of paraffin have been removed from one well by this operation. Some operators prefer to steam wells through an auxiliary tubing string, because the well may be pumped during steaming and because steaming can be continued for a long time. However, the difficulties encountered in running the auxiliary steaming string into the well have limited its use.

COSTS AND RESULTS OF STEAMING: Steaming is reported to

TABLE 1

Summary of Analysis of Rod Wax 2 from Clay District, West Va.

(Melting point of crude rod-wax sample 161.9° F. (72.1° C.); weight of crude rod-wax sample 297 grams; weight of oil-free rod-wax sample, 202 grams, 68 percent; weight of crude oil removed from rod-wax, 95 grams, 32 percent). Fractions separated from rod-wax with hot acetone and precipitated at 30° F. to form crude-wax fractions.

No.	Weight, Grams	Oil-Free Rod Wax, Percent	Acetone Used, Liters	Color	After Removing Gums and Resins with Fuller's Earth: Weight, Grams	Oil-Free Rod Wax, Percent	Color	Melting Point °F.
F 1	8.9	4.4	2.0	Light Brown	7.7	3.8	White	135.8
F 2	7.7	3.8	5.0	" "	6.3	3.1	"	151.0
F 3	8.2	4.1	10.0	" "	6.5	3.2	"	160.8
F 4	11.5	5.7	20.0	" "	10.3	5.1	"	167.8
F 5	11.5	5.7	60.0	" "	10.2	5.0	"	169.1
F 6	11.7	5.8	75.0	" "	11.2	5.5	"	172.2
F 7	12.2	6.0	90.0	" "	11.2	5.5	"	172.8
F 8	13.7	6.8	105.0	" "	12.6	6.2	"	174.1
F 9	8.8	4.4	105.0	" "	7.5	3.7	"	175.1
F 10	9.5	4.7	60.0	" "	8.8	4.4	"	175.9
F 11	8.5	4.2	60.0	" "	7.8	3.9	"	176.5
F 12	8.4	4.2	75.0	" "	7.8	3.9	"	176.8
F 13	7.5	3.7	65.0	" "	6.9	3.4	"	177.3
F 14	7.5	3.7	75.0	" "	6.9	3.4	"	176.8
F 15	8.2	4.1	75.0	" "	7.6	3.8	"	175.2
F 16	8.7	4.3	*11.0	" "	6.4	3.2	"	175.2
F 17	9.0	4.5	*16.0	" "	8.3	4.1	"	175.8
F 18	7.3	3.6	*16.0	" "	6.8	3.4	"	175.8
F 19	5.9	2.9	15.0	" "	5.5	2.7	"	179.6
F 20	12.3	6.1	Residue	" "	5.6	2.8	"	178.6
Total	187.0	92.6	....	.....	162.9	80.6	.....	.....

* 75 percent acetone, 25 percent ethylene dichloride. Data from C. E. Reistle, Jr., Bureau of Mines Bull. 348, p. 132.

Summary of Oil-Free Rod-Wax Fractions

Total white-wax fractions	80.6
Total gums and resins	18.6
Total "asphaltenes"	0.0
	99.2
Loss	0.8
	100.0

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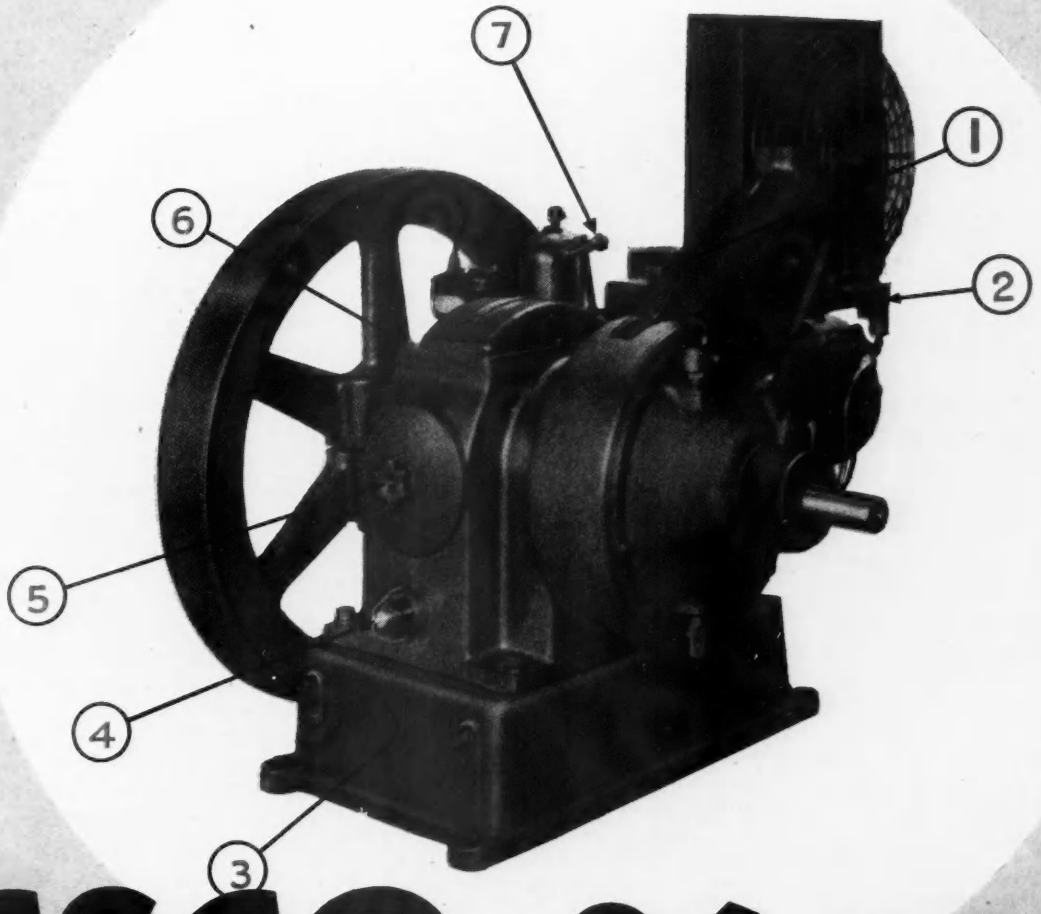

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cost an average of $100 to $150 a well, which includes the expenses of hauling and setting a boiler, pulling and running tubing and rods, and the charges for fuel and water.

Figure 3 shows the oil production rates of two wells which were steamed during cleanout operations. The production history of Well J-1 provides an excellent example of the effect upon the production rate caused by the accumulation of paraffin in the well. On the production graph of Well J-1, the lower dashed lines are extensions of the abnormal decline in production rate caused by the deposition of paraffin. Both the 1938 and 1940 cleanout and steaming jobs on Well J-1 resulted in bringing up the production rate of the well back to its normal decline, as shown by the upper dashed line. The production history of this well shows that it was again in need of treatment in 1943.

Abnormal decline in production rates due to the accumulation of paraffin also are evident in the graphs for Wells K-17, E-31 and A-63 (Figure 4). K-17 and E-31 maintained higher production rates after steaming than at any time during the previous year. A-63 was drilled deeper in February, 1934, and found production in the Berea sand. The well's production, however, dropped from a monthly rate of 1820 barrels of oil for April, 1934, to 480 barrels for August, 1934. A ten-quart shot failed to halt the rapid decline in production rate, which was believed due to the accumulation of paraffin in the well. In December, 1934, the well was steamed for five days through a string of 1¼-inch tubing run in the well alongside the two-inch pumping string, and the well was pumped continuously while steaming. Unfortunately, the 1¼-inch tubing wrapped itself around the two-inch tubing during the job and was parted and dropped when an attempt was made to remove it from the well after steaming. The parted string of tubing was left in the hole until June, 1934, when the two-inch tubing also parted and had to be fished out.

Removal of Paraffin by Heat-producing Chemicals

The heat generated by the reaction of chemicals and water has been used to melt paraffin deposits in wells and clean deposited paraffin from the producing sand face. Four such reactions with water are used in cleaning out wells in the Applachian area: (1) calcium carbide; (2) caustic soda (lye); (3) caustic soda and metallic aluminum; and (4) Berite, a patented cleaning mixture.

USE OF CALCIUM CARBIDE: Calcium carbide reacts with an excess of water to form acetylene gas and calcium hydroxide, which is virtually insoluble in water. Theoretically, 840 British thermal units are generated by the reaction of one pound of carbide with water. In treating a well, the heat lost to the sand and carried away by the acetylene gas is estimated to amount to one-half of the heat generated; so, for practical purposes, from each pound of carbide put into a well only 420 Btu of the heat generated are available to raise the temperature of the liquid in the well. The quantity of calcium carbide required depends on the nature of the liquid in the well; if the well contains only water, 350 Btu of heat will increase the temperature of each barrel (42 gallons) of water about 1° F., whereas only an approximate 140 Btu are needed to increase the temperature of a barrel of oil 1° F.

The previous discussion of the nature of paraffin deposits indicates that the removal of paraffin from a well by heat requires a temperature in the well of about 200° F. To achieve this in the average Appalachian well, the treatment should supply enough heat to increase the temperature of the liquid in the well by about 130° F.

To raise the temperature of a barrel of water 130° F., 109 pounds of calcium carbide are needed. However, a marked saving in the cost of heating the liquid in a well with calcium carbide may be obtained by using only the quantity of water actually needed to react with the carbide and using crude oil or kerosine to fill the hole to the top of the producing sand. In addition to reducing the quantity of carbide needed, the solvent action of the heated oil will aid in removing paraffin and perhaps cause less caving of the sand than hot water. The recommended unit proportions of calcium carbide, water and oil for raising the temperature in a well to 200° F., are 63 pounds carbide, 12.6 gallons of water, and 29.4 gallons of oil or kerosine. The mixture of these quantities has a volume of one barrel, and the unit proportions must be multiplied by the volume of the shot hole in barrels to obtain the quantity of carbide, water and oil needed for a particular well.

Young[17] points out that before treating a well with calcium carbide, the well should be cleaned to bottom, the sand face washed down, and the well bailed. The volume of liquid necessary to fill the well to the top of the sand should be measured, so that the amount of carbide, water and oil can be calculated. To do this, a bailer with a dump rod of the correct length to dump the bailer at the top of the sand is used. Water is measured into the bailer from a barrel on the derrick floor, and when the bailer returns to the top of the hole with water, the driller knows that the shot hole is full of liquid. The well is then bailed down, and the computed volume of water and oil are placed into the well with the dump bailer. The dry calcium carbide is then slowly poured into the well. To prevent bridging, carbide particles smaller than 1½-inch in diameter are used. The tools are then run into the well and operated off bottom with enough motion to agitate the mixture in the well for four or five hours, to aid the reaction and to wash the sand face.

Before running the tools into the well, tool joints must be made up carefully; otherwise, the expansion caused by the heat generated in the well might cause a pin to "jump" and thus cause a fishing job. The cleanout crew also must be careful not to breathe acetylene gas or to have open flames nearby, as the gas is both toxic and inflammable. After the period of agitation, the well is bailed to remove the melted paraffin. Valuable information, helpful in subsequent jobs, will be obtained if a maximum-reading thermometer be run with the first trip of the bailer to determine the temperature of the liquid in the hole, and this temperature reading is entered on the job record together with the quantities of carbide, water and oil used. After bailing the well, the shot hole is washed down to insure removal of the lime precipitated during the reaction.

Figure 5 plots the production rates of two wells treated with carbide.

USE OF CAUSTIC SODA: The heat liberated by mixing caustic soda (lye)

TABLE 2

(Unit Quantities of Chemicals and Water Required to Raise the Temperature of Liquid in a Well from 70° to 200° F.

METHOD	Estimated Effective Btu./pound of Dry Chemicals*	Recommended Quantities On Basis of One Gallon of Shot-Hole Volume	Recommended Quantities For One Barrel (42 gal.) of Shot-Hole Volume
Calcium, Carbide and Water	420	1.5 lb. calcium carbide 0.3 gal. water 0.7 gal. oil	63.0 lb. calcium carbide 12.6 gal. water 29.4 gal. oil
Caustic Soda (lye) and Water	210	3.7 lb. caustic soda† 1.0 gal. water	156.0 lb. caustic soda† 42.0 gal. water
Caustic Soda, Metallic Aluminum, and Water	810	0.14 lb. aluminum 0.56 lb. caustic soda 0.17 gal. water 0.83 gal. oil	6.0 lb. aluminum 24.0 lb. caustic soda 7.2 gal. water 34.8 gal. oil

* Allows for 50 percent heat loss. † These are maximum amounts of caustic soda that can be used, but calculated temperature increase will be only 93° F., or from 70° to 163° F.

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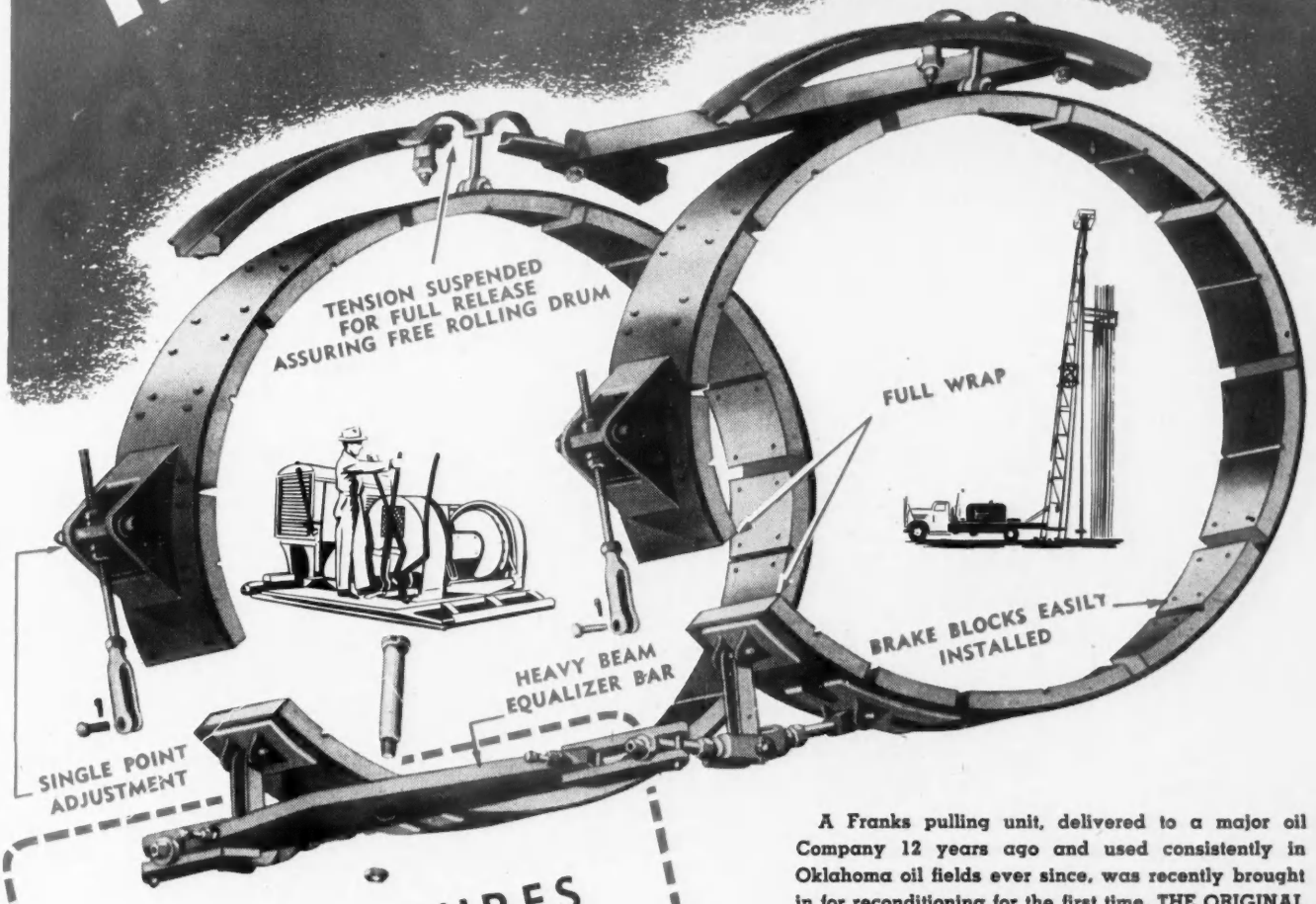

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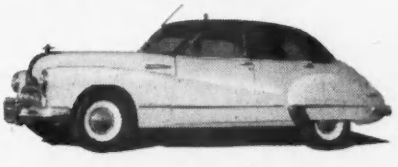

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and water is sometimes used to heat liquid in the shot hole of a well to remove paraffin. About 420 Btu of heat theoretically are generated when one pound of crystalline caustic soda is dissolved in water. However, if more than four pounds of caustic soda are dissolved in a gallon of water, the quantity of heat generated per pound of caustic soda decreases rapidly, so that for the purpose of heat generation, caustic soda concentrations greater than 3.8 pounds per gallon of water (156 pounds per barrel) are impracticable.

If in treating a well a heat loss of 50 percent is assumed to occur, then at the maximum heat-generating concentration of 156 pounds of caustic soda per barrel of water the temperature of the water in a well can be increased only 93° F., if the mixing is done in the shot hole. The temperature of the average Appalachian well would be increased from 70 to 163° F. It is questionable whether the paraffin in a well would be completely melted at this temperature, and in any case the use of caustic soda would be more expensive than calcium carbide for generating heat in wells.

USE OF CAUSTIC SODA AND ALUMINUM: Although the reaction of caustic soda (lye) and metallic aluminum was not used in any of the cleanout jobs studied, it has been used successfully to remove paraffin from wells in the Appalachian area,[18] where it has proven the most efficient of the heat-producing chemical reactions commonly used to remove paraffin deposits. To heat liquid in a well, the caustic soda in solid form is dissolved in water in the well, and metallic aluminum in the form of shavings, slugs or pellets is added. As a result of the reaction, sodium aluminate which is soluble in water, and free hydrogen (gas) are formed. Theoretically, the reaction of one pound of dry chemicals (0.2 pound of aluminum and 0.8 pound caustic soda) will generate 1620 Btu of heat when mixed with water. However, heat losses to the sand and impurities in the chemicals are estimated to account for at least half of the heat generated, so that of the heat generated by each pound of chemicals only 810 Btu will be available to raise the temperature of the liquid in the well. If the shot hole is filled with water, 60 pounds of chemicals (12 pounds aluminum and 48 pounds caustic soda) will be needed to raise the temperature of one barrel of water from 70 to 200° F. However, as discussed previously, the quantity of chemicals needed to raise the temperature of the liquids in the well to 200° F. may be reduced to a minimum by having in the well only the amount of water needed for the reaction (¼ gallon per pound of dry chemicals) and using oil or kerosine to fill the well to the top of the producing sand. Upon this basis, each barrel of oil or kerosine in the well would be heated from 70 to 200° F. by adding 35 pounds of dry chemicals (seven pounds aluminum and 28 pounds of caustic soda) and nine gallons of water. The volume of the well bore to the top of the sand must be known, so that the total quantities of aluminum, caustic soda and water and oil needed can be calculated.

Treating wells with caustic soda and metallic aluminum is carried out in much the same manner as was outlined for calcium carbide. The required volume of water is placed in the well with the dump bailer, and the calculated quantity of caustic soda is slowly poured into the well (or lowered in screen-wire containers tied to the bailer dart). Next, about two-thirds of the required volume of oil is poured down the well, then the metallic aluminum pellets are dropped into the well and washed down by pouring in the remainder of the oil.

Table 2 is a comparative summary of the quantities of chemical required by each of the three reactions discussed in order to raise the temperature of the liquid in a well from 70 to 200° F. if 50 percent of the heat generated is assumed to do no useful work in raising the temperature of the liquid.

USE OF BERITE: The records of some of the cleanout jobs studied show that Berite, a patented, heat-producing chemical treatment, was used to remove paraffin from the producing sand. Its use involves mixing two compounds, which are furnished in separate packages, with water in the shot hole of a well. The recommendations of the manufacturer are to use eight cans of each compound for a well penetrating 40 feet of oil sand with a 40-foot pocket below the bottom of the sand. About two barrels of water are used to wash each of the chemicals down the well, and the well is filled to the top of the sand with oil. Temperatures of the liquid in the shot holes after using the treatment were measured in only a few wells and ranged up to 100° F.

Application of Open Flame to Sand Face of Well

A method of applying heat to the producing sand face to melt paraffin by burning an open flame in the shot hole was tried some time prior to 1932 in several wells in the Appalachian area, and the experiments attracted attention in other areas.[19, 20, 21] Seven wells were heat-treated with an open flame during cleanout, but no data on the cost of these jobs are available. Upon the basis of the quantity of oil gained 600 days after the cleanout jobs and the production rates of the wells before cleaning, four of the seven jobs may be considered as having been successful.

In order to maintain an open flame in the shot hole of a well, the well was bailed dry, and tubing with a perforated nozzle at the lower end was run into the well. Air and natural gas were compressed separately and mixed to form a combustible mixture and injected into the tubing. A railroad signal fuzee was dropped into the well to ignite the compressed gas at the burner. Evolution of heat from the open casinghead was taken as proof that the gas was burning at the bottom of the well. A great deal of trouble was experienced in keeping the flame burning under the surface of liquid in the well, so that the method was used only in wells that did not fill rapidly with fluid. Where the flame was kept burning against the exposed sand face, it is reported that paraffin deposits were coked, and pieces of fused sand sometimes were recovered when the wells were cleaned later with tools. Apparently the method was most successful where the heat caused the sand to cave sufficiently to expose a fresh sand face. The use of an open flame directly against the sand is not recommended, and, so far as is known, the method is no longer used.

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Comparison and Rating of Two-Cycle and Four-Cycle Spark Ignition

DUE to different methods of testing and rating internal combustion spark ignition engines, it is often very difficult to arrive at an accurate comparison between makes and types. This is especially true if both two- and four-cycle engines are under consideration.

Since all internal combustion reciprocating engines operate on either the two-cycle or four-cycle principle, consideration of the fundamental difference in the two types should simplify comparison.

The term "four cycle'" is an abbreviation of "four-stroke cycle" and refers to the number of strokes of the piston required to complete the combustion cycle of the engine. The first is the intake or induction stroke which is a down stroke during which the air and gas mixture is drawn into the cylinder. The next stroke as the piston moves up is the compression stroke during which the mixture is compressed to about one-sixth its original volume and to a pressure of about 100 pounds.

Just before the piston reaches the top the spark plug fires the mixture, and as it burns the piston is forced down on the third stroke which is called the expansion or power stroke. The fourth stroke which returns the piston to the top and completes the cycle is called the exhaust stroke.

Since all four-cycle engines operate as outlined above, the horsepower they can develop is governed by certain laws which apply regardless of make or type of construction. The only exception is the use of supercharging, and since this method of increasing horsepower is seldom used on oil field gas engines it will not be considered here. Four-cycle engines of the same displacement operating at the same speed will develop the same horsepower.

The term "two cycle" means "two-stroke cycle," which indicates that the engine completes its combustion cycle in two piston strokes.

The first stroke begins as the piston is forced downward by the expanding gases in the cylinder, and power is delivered to the crankshaft until the exhaust port is uncovered. The remainder of the downward stroke and the first part of the upward stroke exhaust the burned gases and charge the cylinder with a fresh mixture for the next cycle. When the piston covers the ports compression begins and continues until the piston reaches the top where the charge is fired, and the next cycle begins. Other types of two-cycle engines use valves to obtain higher output, but since they are not used for oil well pumping, they will not be discussed here.

Since the two-cycle engine fires twice as often as the four-cycle, it might appear that it should develop twice the horsepower of the four-cycle engine of the same size operating at the same speed. Actually, the two-cycle will develop only about 70 percent more due to the less efficient scavenging of the valveless design. However, due to the heavier construction usually found in two-cycle engines, it is possible to rate them at about 80 percent of capacity. This is also due to the fact that the two-cycle engine develops its rated horsepower at a lower mean effective pressure. Factors which determine the horsepower are displacement and speed. Displacement may be determined by the following simple formula:

$$\text{area of piston} \times \text{length of stroke} \times \text{number of cylinders}$$

In discussion of engines, the term mep is often used. It is the average pressure applied to the crankshaft by one cylinder during each combustion cycle. It varies directly with horsepower output.

For comparison, it is usually assumed that un-supercharged four-cycle spark ignition engines develop approximately 100 pounds mean effective pressure at full load, and that this drops in direct proportion as the load drops. In other words, an engine loaded to 70 percent of its capacity may be said to be developing 70 pounds mep. Since it is never desirable to operate a four-cycle engine in continuous service, above 70 percent of its capacity, nearly all manufacturers recommend that engines not be loaded above 70 pounds mep.

The other limiting factor in engine selection for continuous duty is piston speed, determined by the following formula:

$$\text{stroke} \times 2 \times \text{rpm}$$

From the formula it can be seen that the longer the stroke of an engine the slower the engine must run to keep the piston speed below the accepted continuous duty limit of 1000 feet per minute. The importance of limiting piston speed can be readily understood when it is considered that the piston must stop and start in the opposite direction at each end of the stroke. Thus, since the weight of the pistons and other reciprocating parts increases in proportion to the size of the engine, piston speed must be kept low enough to prevent overloading crankshaft and bearings.

The following formula will help to determine whether the engine in question is being fairly rated or over-rated. If the horsepower is known, the mean effective pressure may be found as follows:

$$\frac{L \times A \times N}{HP \times 33{,}000} = \text{mep}$$

For example, un-supercharged gas engines seldom develop over 100 pounds mep at full load, and should not develop above 70 pounds at the recommended rating for continuous operation. If the mep is known the horsepower may be found as shown below:

$$\frac{P \times L \times A \times N}{33{,}000} = \text{HP of one cylinder}$$

P = mep, L = length of stroke in feet, A = area of piston in inches, N = number of power strokes per minute.

It is to be remembered that in the four-cycle engine there is a power stroke every other revolution and in the two-cycle every revolution.

Power curves for engines often show maximum corrected horsepower. Such a rating should never be used in selecting an engine as it is the maximum developed under laboratory conditions seldom, if ever, duplicated in the field. Corrected horsepower is determined by calculating what an engine would develop above its actual output if the heat value of the fuel, barometric pressure, air temperature and all other factors effecting output were brought up to the API standard. Altitude should be considered. The loss in horsepower with increased altitude is about 3 percent per 1000 feet.

Another consideration is the fact that some ratings are given for stripped engines, while others are for complete power units. Power curves should always be checked for this item as it usually makes about 10 percent difference in the output.

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CORROSION FATIGUE of Oil Well Equipment

By B. B. MORTON,
Development and Research Division, The International Nickel Company, Inc.

FAILURE of oil well equipment by corrosion fatigue has engaged the attention of many competent investigators for some time. Dr. F. N. Speller led his Eastern District group of the Topical Committee on Materials, API, in a series of studies some time ago that bore on this subject. The results were reported to the API.[1] H. R. Copson's[2] discussion of "Galvanic Corrosion in Salt-Water Solutions" presents a succinct statement of corrosion in general and outlines principles that must be understood in order to cope with stress-corrosion of oil well equipment. This paper is part of the work done under Dr. Speller's leadership, referred to above. The work by Wescott and Bowers[3] on the failure of sucker rod materials under stress-corrosion conditions is now looked upon as a classic. Grant and Texter collected much experience and reported it in their paper, "Cause and Prevention of Drill Pipe and Tool-Joint Trouble."[4] This paper should be considered a "must" for one studying failure of oil well drilling equipment. Attention is also called to a recent report from Battelle[5] of work done in connection with the study of pipe failure by corrosion fatigue.

General Considerations

FATIGUE FAILURE: Generally when a static force acts upon a steel the metal resists the force to the limit of its strength as determined by tensile tests. If the force is of such a magnitude that it does not exceed the yield strength of the metal, the force and reaction may remain in equilibrium over a long period of time with no appreciable effect upon the metal. If, however, the force is of a recurring nature of fairly high frequency, the ability of the steel to resist failure is reduced to about one-half, or less, of the value it possessed in resisting a stationary force. The value of one-half the ultimate strength of steel applies only in the case of a part with a highly polished surface and represents the maximum obtainable by such treatment. Scratches, notches and sharp changes of dimension all serve further to reduce the resistance of a metal part to recurring stresses. Under corrosive conditions there is apparently no true endurance limit, and failure becomes a function of stress intensity and the number of recurrences (cycles). Figure 1 shows the effects of notches in reducing the endurance limit of a steel part and especially illustrates the pronounced influence of notch sharpness in its deleterious effects upon the resistance to repeated stresses.

CORROSION OF STEEL: The corrosion considered in this paper is electrolytic in nature in that it depends upon a difference in potential in parts of the metal, upon the presence of an electrolyte (water contaminated with soluble, ionized salts), and upon a depolarizer as oxygen or a low pH value that will permit the evolution of molecular hydrogen. In the pH range 6.6 and higher the presence of oxygen is considered essential for the corrosion to proceed in the case of steel.

Copson[2] so well outlines the mechanism of the corrosion considered in this paper that his opening subhead is reproduced herewith:

Normal Corrosion

"The most common form of corrosion of iron by neutral salt solutions requires the presence of oxygen. In its simplest terms the reaction may be pictured as follows:

$$2\,Fe + O_2 + 2H_2O \rightarrow 2\,Fe(OH)_2 \quad (1)$$

According to the electrochemical theory of corrosion, this reaction takes place in two parts: 1, at anodic regions:

$$2\,Fe \rightarrow 2Fe^{++} + 4e \quad (2)$$

2, at cathodic regions:

$$4H^{+} + O_2 \rightarrow 4H \rightarrow 2H_2O \quad (3)$$

$$4e + O_2 + 2H_2O \rightarrow 2O^{--} \rightarrow 4(OH)^{-} \quad (4)$$

In neutral salt solutions well supplied with oxygen, the cathodic reaction will tend to follow equation (4); i.e., absorbed oxygen will react with a water dipole to give hydroxyl ions. In slightly acid solutions the cathodic reaction will tend to follow equation (3); i.e., the electron jump will tend to be to the hydrogen ion rather than to the oxygen. In either case oxygen is required for the completion of the cathodic reaction.

"The rate at which the corrosion reaction proceeds will be influenced by a large number of factors—of which the oxygen supply, the temperature, composition and relative motion of the solution, and the formation of films of corrosion product will be most important. Very often the oxygen supply is the controlling factor."

From the above, it will be evident that corrosion, such as here considered, results from the tendency of iron to go into solution in an electrolyte and for hydrogen to plate out on the metal surface. The plating of the hydrogen tends

THIS ARTICLE covers phases of an investigation of corrosion-fatigue phenomena which must be considered in any program looking toward reduction or elimination of equipment failures through prevention of incipient corrosion areas which, in turn, serve as focal points for stress-corrosion failures.

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to block the corrosion; hence, its removal by oxygen (3 or 4 above) or by molecular release is a practical necessity for corrosion to continue.

The effect of oxygen in promoting corrosion is shown in Table 1, which is based upon Table 4 of the paper by Dr. Copson.[2]

The formation of pits, which in turn act as stress raisers, depends upon potential differences within small areas of the metal surface. The avoidance of these local differences of potential is practically impossible. Their occurrence can be promoted by the presence of scale, by composition differences, by varying stream velocity, and possibly by variations in worked conditions of the walls.

CORROSION FATIGUE OF DRILL PIPE: Recognizing that the stresses encountered in drilling are recurring in nature, and hence depend upon the endurance limit of the steel for resistance, it readily can be visualized that corrosion by introducing notches can adversely affect the endurance limit. As pointed out above, there appears to be no true endurance limit under corrosive conditions and the life of the part depends upon a low order of stress. This fact appears to have been noted by operators at an early date, and the suggestion repeatedly appears in the literature to use drill collars for needed weight on the bit and to keep the drill pipe in tension. This is often worded as a warning against keeping the pipe columns in compression. This wording may be unfortunate in that it may imply that compressive stresses are conducive to fatigue failure. Actually, it has been shown that fatigue failure does not occur under compressive stresses and that a part must be in tension to fail in fatigue. The significance of compressive loading is that the pipe string represents a column of high slenderness ratio—hence, one that would tend to deflect and to buckle. As the column deflects, tensile and compressive stresses are set up in the deflected areas on opposite sides. As the pipe rotates, the stresses may vary the full range from compressive to tensile. This is a condition most conducive to fatigue failure. The recommendation regarding use of tension is sound. The wording in some cases could be better chosen.

Corrosion fatigue of drill pipe appears to have one identifying characteristic, in that it generally takes place at the inner wall of the tubing and is associated with many cracks in a given area.[4] Figures 2 and 3 show the location and also the propagation at a fatigue crack at the inner wall of a drill pipe. An explanation of the attack at the inner wall may be that the oxygen associated with the mud is more concentrated at the entrance, i.e., bore of the tube. It has been generally remarked that corrosion fatigue rarely, if ever, occurs from the outside of the pipe. The explanation offered is that the mud rounds out the cracks or pits and thereby reduces their stress raising abilities. This explanation may be entirely correct, but in view of Dr. Speller's statement that "a very small amount of highly-localized corrosion" (1, p. 241) may cause considerable damage, it is difficult to visualize the attack taking place on the outer wall with no crack starting during the time that is required for the mud to round out the base of the pit. An oxygen balance in the mud of a well where corrosion fatigue is a factor might throw some light on this subject. If the oxygen is consumed largely in the pipe, this might offer another explanation of the absence at the outer wall of corrosion pits of dangerous shape, i.e., sharp bottoms. Figure 4 shows a case where corrosion fatigue at the outer wall was suspected.

In view of the fact that stresses and also the elements of corrosion, namely, water contaminated enough to be a conductor and oxygen, are present in many drilling operations it is a matter of wonder that corrosion fatigue is not more of a factor in oil well drilling. The question of why it is not is worthy of consideration. The answer must be associated with the factors that prevent marked corrosion. These factors may involve matter that reacts with oxygen, thus removing this prime cause of corrosion in neutral or basic solutions; or a material that acts mechanically to block the walls against contact with oxygen; and possibly an inhibitor. The presence of colloid suspension in most muds that have a pH in excess of about 6.6 serve possibly a dual purpose of mechanically adsorbing oxygen and of forming a protective film over the metal part. It is noteworthy that corrosion fatigue is most in evidence where the presence of chloride-bearing salts tends to flocculate the colloids. It has been reported that some muds contain organic matter that consumes rapidly the oxygen that enters into solution in the mud. The presence of a natural inhibitor has not been reported. The action of inhibitors of the oxidizing type as the chromates has been

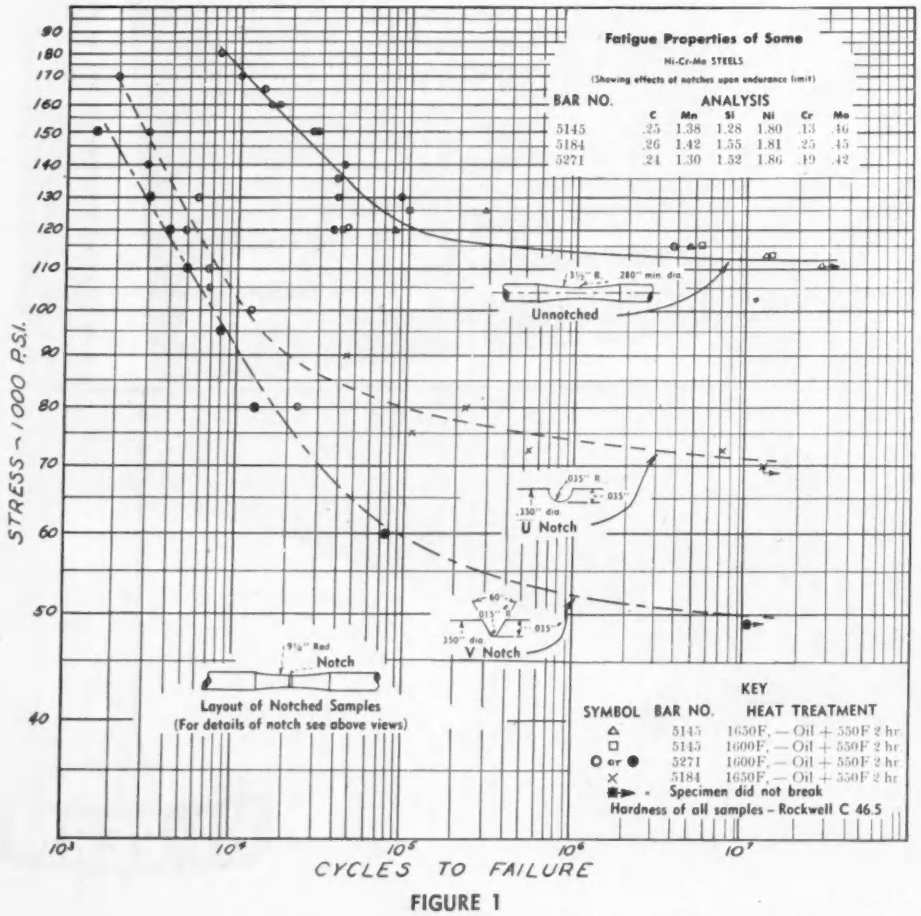
Fatigue Properties of Some
Ni-Cr-Mo STEELS
(Showing effects of notches upon endurance limit)
BAR NO. ANALYSIS
C Mn Si Ni Cr Mo
5145 .25 1.38 1.28 1.80 .13 .46
5184 .26 1.42 1.55 1.81 .25 .45
5271 .24 1.30 1.52 1.86 .19 .42
Unnotched
U Notch
V Notch
Notch
Layout of Notched Samples
(For details of notch see above views)
KEY
SYMBOL BAR NO. HEAT TREATMENT
5145 1650F. — Oil + 550F 2 hr
5145 1600F. — Oil + 550F 2 hr
5271 1600F. — Oil + 550F 2 hr
5184 1650F. — Oil + 550F 2 hr
Specimen did not break
Hardness of all samples – Rockwell C 46.5
STRESS – 1000 P.S.I.
CYCLES TO FAILURE

FIGURE 1

Courtesy Crucible Steel Company of America

TABLE 1

Effect of Oxygen Upon Corrosion Rate of Carbon Steel in Artificial Sea Water

Temperature	Aeration	pH	CORROSION RATE M.D.D.*	CORROSION RATE M./Y.*
120° F.	Open to air, but no air added.....	5.5	82.0	15.0
120° F.	Air content reduced by saturating solution with N_2 and H_2.....	5.5	16.0	2.93

Note: Motion in both cases 16 feet per minute.
* M.D.D. = Milligrams per square decimeter per day.
M./Y. = mils per year.

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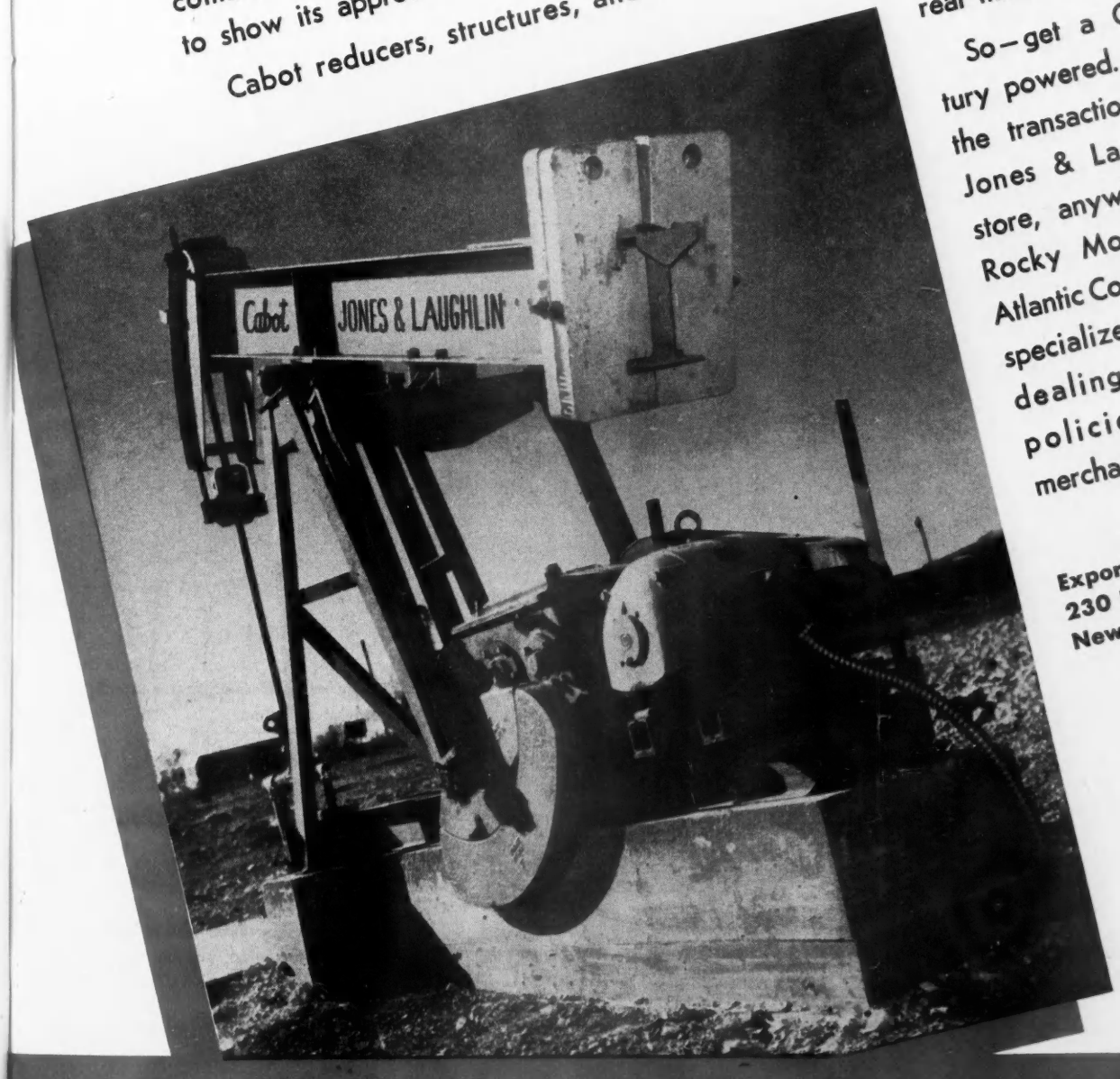

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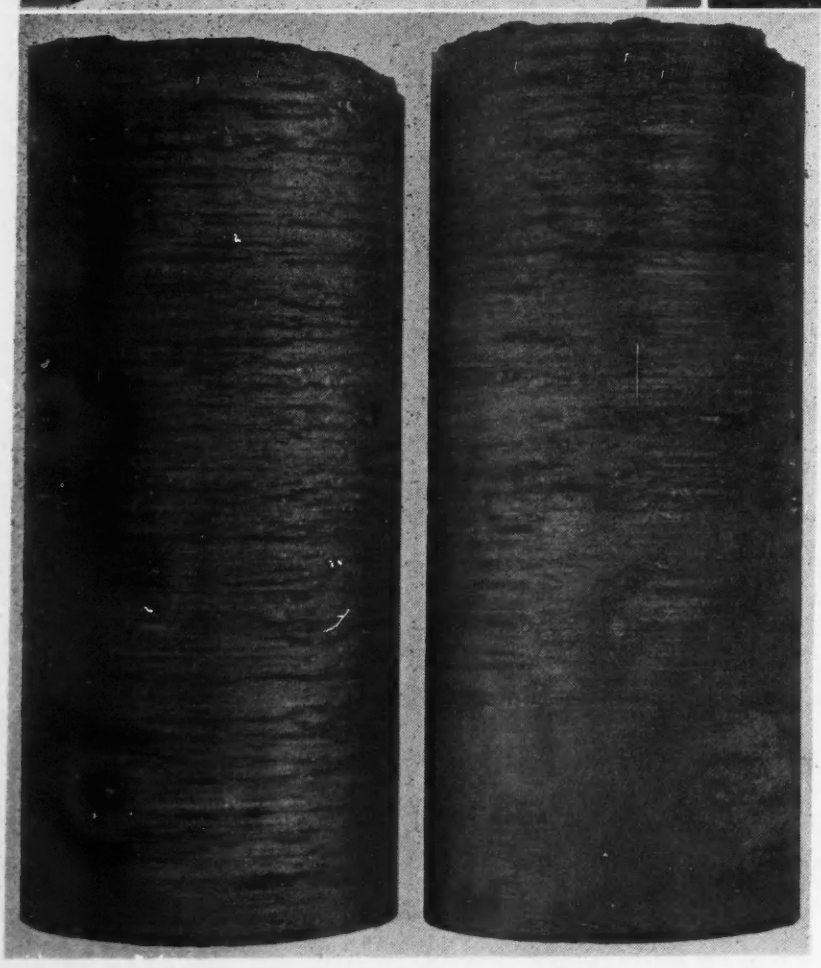

FIGURE 2 (top left). **Internal corrosion fatigue crack in Grade D drill pipe.**

FIGURE 3 (top right). **Cross-section of a crack of Figure 2.**

FIGURE 4 (below). **Fatigue cracks at outer wall of Grade C drill pipe. (Corrosion fatigue in area gouged by slips.)**

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reported upon[5] and possibly can be employed under some conditions. Many inhibitors have toxic or harmful properties that will limit their use. It is well to note also that not all pits are efficient stress raisers, and the probability is that only a very few can act efficiently in this capacity. This can be seen when a corroded piece is pulled—cracks, incipient cracks and enlarged pits will appear on the pulled surface. The outlines of a pit formed under corrosive conditions is regulated by many factors, of which only a few are known. The point is that considerable corrosion must occur in a given area to produce an effective stress intensifying pit. This factor and the presence of dispersed corrosion in an area can be accredited somewhat with the relatively small amount of corrosion fatigue so far reported. Conversely, the factors that intensify local corrosion, as the presence of oxygen and soluble salts, high local velocity, and also local causes of differences in potential, all tend by increasing corrosion to produce a "stress raiser" in the form of very sharp-bottomed pits. At least, they tend to increase the probability of such pits occurring, and in this matter we seem to be dealing in probabilities.

The beneficial effects to be derived from a drilling mud can be seen from Table 2. The data of this table are from the paper by Dr. Copson (Tables 5 and 7).

Shielding the Wall

Since corrosion is the important factor in corrosion fatigue of drill pipe, and since it is associated with the presence of oxygen and water in contact with the steel of the pipe, the most logical method of combating this failure is by reducing corrosion, and this can best be accomplished by shielding the wall by coating it with an impervious, resistant, lining. The efficiency of this method is dwelt on by the report from Battelle.[5] Plastic coatings of the types described are proving themselves of value. Attention may be directed to metallic coatings. The writer has been informed (in communications from S. G. Bart, president, Bart Industries, Belleville, N. J.) that two or more strings of nickel plated oil well tubing are being installed as part of the work of resisting the corrosion by distillate wells. Nickel plating has been found highly resistant to hydrogen sulphide in West Texas wells and to the peculiar corrosion of the distillate wells. This latter corrosion is associated with carbon dioxide. Nickel-plated drill pipe, flashed with chromium to resist the scouring action of the mud, suggests itself for locations where a metallic lining is desired.

The use of lining has the added effect of protecting the pipe while it is on the surface. While corrosion fatigue can take place only during operation, corrosion can go on continually and its damaging pits can be formed in service or out. It is quite probable that protection of drill pipe should begin at the mills; in any case, before corrosion starts. It is well to recall Dr. Speller's warning about the slight amount of corrosion required to damage a drill pipe.

It may be well to consider that shielding the inside of a drill pipe may move the corrosion down and toward the outside due to the fact that the oxygen is not consumed. An oxygen-consuming reagent should possibly be added to the mud to remove the oxygen.

The feeling that low additions of alloys to steel will not produce a material sufficiently resistant to corrosion to prevent corrosion fatigue failure of drill pipe appears well founded. More highly alloyed material may do so. Dr. Speller[1] has mentioned that "under some service conditions, when the rate of stress alternation is relatively slow, it has been found that high ductility of the metal is a significant and important factor in minimizing concentration stress and in delaying or preventing the formation of the sharp crevices which appear as the first stage of corrosion fatigue." With this thought in mind, the excellent mechanical properties of a 0.10 carbon, 9.0 nickel steel are pointed out in Table 3. This steel has been successfully pierced.

The 9 percent nickel alloy steel has given a good account of itself in resisting the corrosion of the distillate wells, and several tubing strings are on order for these wells.

Elimination of corrosion will remove a special case of drill pipe failure, i.e., corrosion fatigue. Fatigue failures will continue to occur with corrosion removed. Fatigue failure usually is associated with mechanical fractures, as scratches, notches, changes in section, and in effects of heat treating. Fatigue failure is most likely when stresses are fully reversed from compression to tension, as has been mentioned before. Care in handling and in prevention of nicks, notches, etc., is the normal method of reducing fatigue failure. Fatigue is not as certain of producing failure as is corrosion-fatigue, since a notched test bar develops a true endurance limit that will assure prolonged life in the case where stresses are below its endurance value. In corrosion-fatigue no such endurance limit is established if the corrosion continues. Since one cannot predict the endurance limit in the presence of unavoidable notches, scratches, pits, etc., the value of low stresses can again be emphasized.

In recapitulation of corrosion-fatigue and fatigue, it can be said: The ability of a steel to resist the unavoidable stresses of drilling can be reduced by the presence of scratches, notches, pits, and other sharp breaks in the surface. Where corrosion is a factor, these imperfections will be introduced by the corrosion, and, among many imperfections so introduced, some will occur that will be especially deleterious in effect. The most logical method of combating corrosion-fatigue appears to be to prevent the corrosion-producing elements, water and oxygen, from contacting the metal either during operation or while the pipe is out

■ CONTINUED ON PAGE 168

About the Author

B. B. MORTON, with the Development and Research Division of The International Nickel Company, Inc., was born in Pulaski, Va., and graduated from the Virginia Polytechnic Institute with a degree in Metallurgy. Before joining International Nickel he was affiliated with Bethlehem Steel Company and Standard Oil Development Company. He is a member of the API, ASME, ASM, NACE and is considered an authority on corrosion.

TABLE 2
Effects of Drilling Mud in Protecting Grade "D" Drill Pipe

Material	Weight Loss M.D.D.	Solution
Grade "D" Pipe	11 avg.	Anahuac Drilling Mud pH 8.9
Grade "D" Pipe	71.5 avg.	Artificial Sea Water pH 5.1—5.8

NOTE: Conditions of time, temperature and motion are the same. Dr. Copson attributes the low rates in the mud as "due either to the basic condition or to protective action of colloids in the mud."

TABLE 3
Typical Mechanical Properties of a 9 Percent Nickel Steel (Carbon—0.10 max.)

Ultimate Streigth, psi	120,000*
Yield Strength, psi	100,000*
Elongation in 2 inches	30 percent
Air Endurance Limit, psi	72,000**
Air Endurance Limit Ratio	.62 percent**

* Data based on communication from H. D. Newell, Chief Metallurgist, Babcock & Wilcox Company, Beaver Falls, Pa.

** The International Nickel Co., Inc.—8½ percent nickel steel of 115,000 psi, U.T.S.

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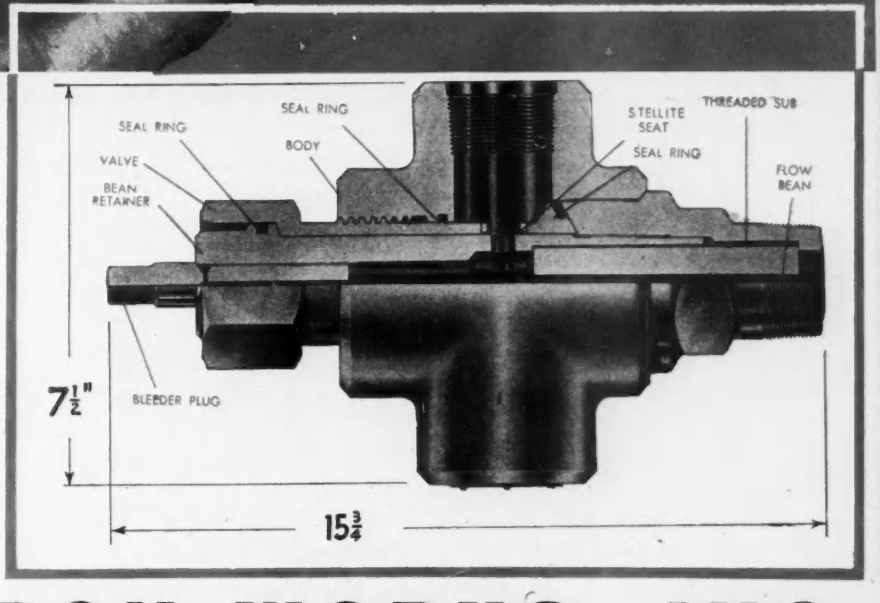

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Condensate PRODUCTION AND CYCLING

Part 15

Basic Data for a Radial Reservoir

THE optimum rate of condensate production for cycling or water injection varies with structure, stratigraphy, pay thickness, permeability, richness of a gas and other factors. The basic data for a radial reservoir herein considered will be used to formulate a cycling program, and pressure maintenance with water for utilization of residue gas, in Part 16.

Structure and Stratigraphy

A radial reservoir having edge water is represented by Figures 15-1 through 15-4. The first figure shows structural contours on top of pay. Productive area is limited on the north side by an E-W fault. The fault is approximately vertical. The other sides of the reservoir are bounded by water. The contours are relative to the elevation of the water contact. The latter is at zero elevation irrespective of depth. Subtract contour elevation from depth to water and obtain depth to top of pay.

The closure is approximately 200 feet. This is a radial-type reservoir and is called the R-1 reservoir. The assumed structural symmetry is for illustrative purposes only.

Figure 15-2 gives the structural contours on the bottom of the pay in the R-1 reservoir. The water contact along the bottom of pay is about 2300 feet from the water contact along the top of pay.

Figure 15-3 illustrates the N-S section through the center of the R-1 reservoir. Most reservoirs have impermeable breaks of considerable areal extent. The individual pay intervals between impermeable breaks usually have variable thickness and permeability. The absence of non-pay in Figure 15-3 is for illustrative purposes only.

Figure 15-4 is the pay thickness in the R-1 reservoir. The region between the zero and 60-foot contours has bottom water. The assumed stratigraphic symmetry is for illustrative purposes. The cycling characteristics of reservoirs in which stratigraphy varies with structural position will be considered later.

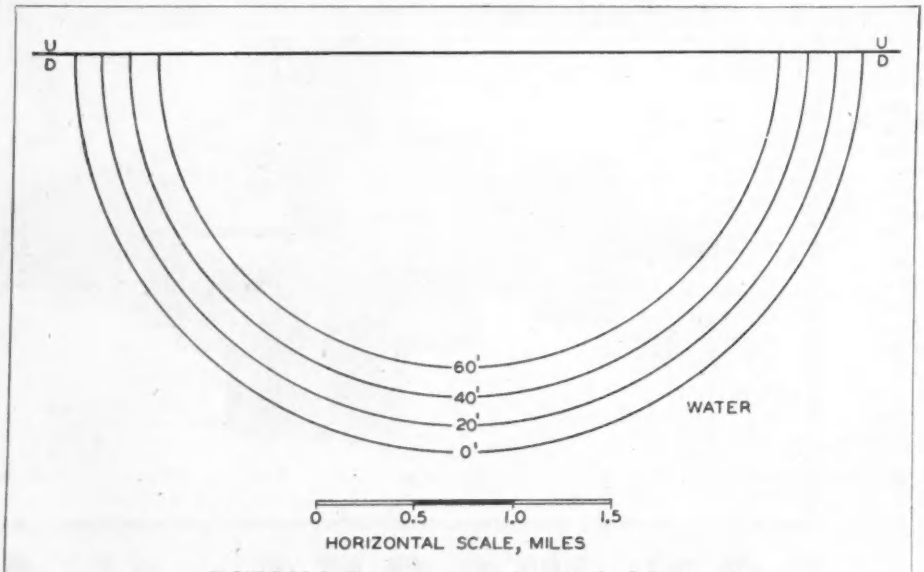

FIGURE 15-1. Contours on top of pay in the R-1 reservoir.

Reservoir Characteristics

Table 15-1 shows some basic data for the R-1 reservoir. The productive area is 4020 acres. The pay thickness averages 48.1 feet. The reservoir space is 1846 barrels per acre-foot. A permeability of 800 millidarcys is assumed for the purposes of illustrating producing and injection wellhead pressures. Reservoir pressure is assumed to be the dew-point pressure P_d for a rich gas. There are 193,300 (1846) or 356.83 million barrels of space occupied by hydrocarbons in the R-1 reservoir.

In-Place Liquid and Gas

The in-place liquid and gas for a given reservoir depends on the properties of rich gas. This point is illustrated in Table 15-2 for the R-1 reservoir in terms of gases A, B and C. The data are relative to the indicated dew-point pressures. The reservoir pressures for which condensation of reservoir liquid is a maximum are estimated at 1500 pounds per square inch absolute for gases A and B and 2500 for gas C. The estimated maximum loss of liquid in the R-1 reservoir is 1,550,000 barrels for gas A; 7,280,000 barrels for gas B; and 24 million barrels for gas C.

The difference in present cost over a

TABLE 15-1
Characteristics of The R-1 Reservoir

Productive area, acres	4020
Average pay thickness, feet	48.1
Acre-feet of pay	193,300
Distance to water contact, feet	10,560
Average porosity, percent	28
Average permeability, mds	800
Average interstitial water, percent of porosity	15
Reservoir space, bbls/acre-foot	1846
Reservoir space, million bbls	356.83

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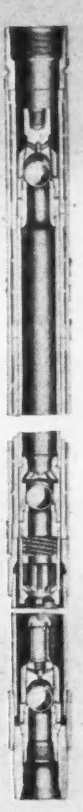

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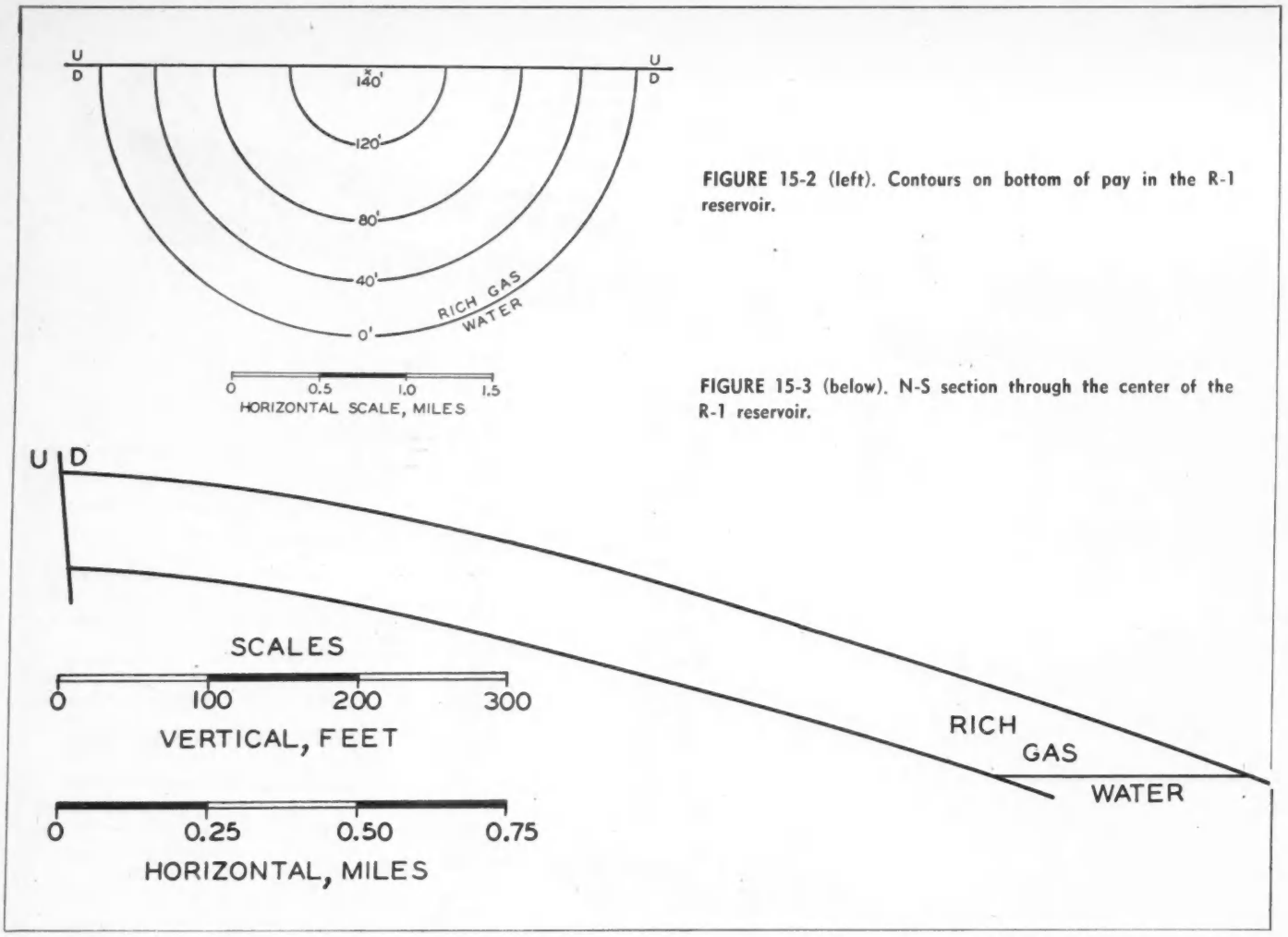

FIGURE 15-2 (left). Contours on bottom of pay in the R-1 reservoir.

FIGURE 15-3 (below). N-S section through the center of the R-1 reservoir.

ten-year period between 100 million per day cycling and non-cycling plants is about $3,400,000. The investment in six injection wells at 85,000 dollars per well is $500,000, making a total of $3.9 million. The present value of 1.55 million barrels at $1.8 per barrel is considerably less than $3.9 million. So cycling of gas A is not warranted on the sole basis of loss of liquid by condensation.

The difference in present cost over a ten-year period between 100 million per day non-cycling and stabilizer plants is about $2,600,000. Suppose extraction after condensation for gas A averages 24 and 14 barrels per million for non-cycling and stabilizer plants respectively. The corresponding liquid extraction difference would be about 3.65 million barrels at the end of ten years. The present worth factor is 0.86 and the present value, 0.86 (3.65) (1.8) or roughly $5.6 million. Therefore, a non-cycling plant would have a $3 million advantage over a stabilizer plant. However, the volume of sales gas available from separators would have a nominal advantage over that from an absorber after shrinkage and fuel.

If residue gas cannot be utilized for n years, the alternatives are to begin cycling now or begin non-cycling with gas utilization n-years hence for gas A. The prospective 7- and 24-million barrel losses by condensation for gases B and C can support pressure maintenance. Gas C will be used to illustrate cycling for no gas utilization and water injection for utilization of residue gas.

TABLE 15-2
In-Place Liquid and Gas for The R-1 Reservoir

	RICH GAS		
	A	B	C
Reservoir temperature, °F	212	220	200
Reservoir pressure, P_d, psia	3870	4660	4490
Composition at P_d, BPMM	27.8	50.2	135.9
Bbls space/bbl C_{4+}	31.07	14.33	5.11
Million barrels of in-place C_{4+}	11.48	24.90	69.83
MCF of rich gas/bbls C_{4+}	35.97	19.92	7.358
Billion feet of in-place rich gas	412.9	496.0	513.8
Propane and lighter, percent of rich gas	97.73	95.74	88.00
Billion feet of in-place residue gas	403.5	474.9	452.1
Maximum condensation pressure, psia	1500	1500	2500
Condensation, million bbls	1.55	7.28	24.00

TABLE 15-3
Rich Gas C Molecular Weight and Gravity

COMPONENT	Y	M	MY
Methane	79.91	16	12.786
Ethane	4.73	30	1.419
Propane	3.36	44	1.478
Isobutane	1.80	58	1.044
N-Butane	1.42	58	0.824
Isopentane	1.04	72	0.749
N-Pentane	0.62	72	0.446
Hexanes	1.42	86	1.221
Heptanes+	5.70	149	8.493
	100.00		28.460=M

Rich gas gravity = 28.46/29 = 0.9814

Reservoir and Well Capacity

Table 15-3 shows the molecular weight and gravity for gas C. The composition is 135.9 barrels per million. The volume factor at 4490 psia and 200° F. is 5.11 barrels of space per barrel of butanes plus. So the compressibility factor is 0.938. In order to estimate the drawdown, assume a 40 million per day producing rate. Then the bottom-hole operating pressure P_b may be obtained as in Table 15-4. A 60 psi drawdown is likely

TABLE 15-4
Estimated Drawdown for 40 Million/Day

Reservoir pressure, psia	4490
Reservoir temperature, °F	200
Compressibility factor	0.938
Viscosity, centipoises	0.04
Well interference factor	0.64
Half distance to injection wells, ft	5,000
Radius of well bore, ft	⅓
log 2d/r=log 30,000	4.48
Completion in pay, ft	60
Average permeability, K, darcys	0.8
P^2_e—P^2_b, million	0.474
P^2_b=20.160—0.474	19.686
P_b, psia	4430
Drawdown, psi	60

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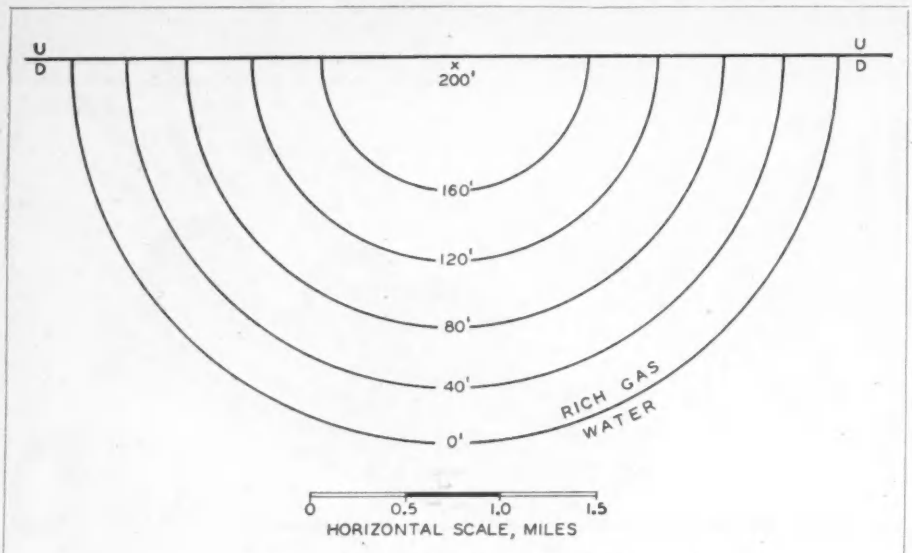

FIGURE 15-4. Pay thickness in the R-1 reservoir.

to produce 40 million per day per well.

In view of the reservoir capacity, 3½-inch nominal size tubing may be used for producing wells. Table 15-5 shows the approximate wellhead pressure for 20-40 million per day per well producing rate. The estimated pressures range from 3010-2170 psia. The pressures are only approximate values. Use average flowing temperature and compressibility factors corresponding to the approximate wellhead pressures and recalculate to obtain more accurate wellhead flowing pressures. After breakthrough of injected gas, producing wellhead pressures will increase progressively by virtue of gravity difference between rich and injected gases.

TABLE 15-5
Producing Wellhead Pressure for 3½" Tubing

Length of tubing, ft	10,000
Average temperature, °F	180
Average compressibility factor	0.90
Gas gravity	0.98
$S=0.0375(0.98)(10,000)/640(0.90)$	0.647
e^S	1.906
$15.1/D^{5.23}$	0.0223
$R=0.0223[640(0.9)Q]^2$	$0.0074Q^2$

Million/day/well, Q	20	30	40
$F=0.0118Q$, million	0.237	0.356	0.474
P^2_b, million	19.923	19.804	19.686
Bottom-hole pressure, psia	4465	4450	4430
Drawdown, psi	25	40	60
R in millions	2.960	6.660	11.840
$R(e^S-1)$	2.682	6.034	10.727
$E=F+R(e^S-1)$	2.919	6.390	11.201
$P^2_w e^S=20,160-E$	17.241	13.770	8.959
P^2_w in millions	9.046	7.224	4.700
Wellhead pressure, psia	3010	2690	2170

Corrosion Fatigue

• CONTINUED FROM PAGE 162

of service. "Pure" fatigue can be combated by avoiding mechanical stress raisers. Both types of fatigue failure respond favorably to reduced stresses in the pipe, especially to reduction in bending stresses. This is accomplished by avoiding compression forces in the pipe string.

CORROSION FATIGUE OF SUCKER RODS: Sucker rods are excellent examples of parts subjected to fairly rapid reversals of stresses from compression to tension. Many such strings operate under corrosive conditions.

Sucker rods fail by normal fatigue, by fatigue originating in the metal rendered brittle by the mechanical presence of hydrogen, and by reduction of cross-section due to corrosion—this last is a special case of corrosion-fatigue.

Normal fatigue occurs as the result of the action of recurring stresses upon some part of the string rendered locally susceptible to failure by the presence of scratches, notches, change of sections or errors of "makeup" of the string. Pin failure is often a case falling under this last heading.

Corrosion-fatigue appears to have two phases. In one case hydrogen is liberated from hydrogen sulfide by the action of corrosion. This hydrogen enters the steel and mechanically renders it brittle. The embrittled steel is apparently quite notch sensitive, and fatigue cracks originate in the embrittled surface from a point that might not, normally, be a focal point for a fatigue crack. In another case, local corrosion sets up a corroded area that introduces a focal point for failure. Often the two conditions apply simultaneously.

Where rapid corrosion takes place the cross-section may be so reduced, and the stresses thereby increased, that fatigue failure by normal stressing above the endurance limit takes place. This can occur without the aid of stress raisers.

Corrosion of sucker rods is a rather peculiar form of corrosion. Pitting and other forms of electrolytic corrosion apparently take place in the absence of oxygen in an electrolyte of nearly neutral pH value. Several explanations have been offered for this; however, the explanations are more in the nature of speculation than the nature of reports of studies. It has been suggested that the pH value in a well is lower than outside where the sample was examined. Also, it is speculated that a catalytic effect causes hydrogen to evolve as H_2.

Wescott and Bowers[3] first, and many since, have shown that nickel is an element that helps retain, under well conditions, a high part of the endurance limit obtained in air. The general use of nickel alloys has been the result of the studies made and the nickel content has gradually increased until rods of 9 percent nickel steel are now in test.

The ability of nickel to protect rods was shown by tests of nickel-plated sucker rods. These rods demonstrated that a plating of about 0.006 inch of nickel can protect steel against corrosion either in hydrogen sulphide brines or in corrosive brines containing no hydrogen sulphide. The requirements are that the plating shall be impervious and that the plate shall not be destroyed mechanically, as by rubbing against a tube wall.

From a standpoint of combined strength, corrosion resistance and wear resistance, rods of "K" Monel (approximately 2/3 nickel, 1/3 copper, with 5 percent aluminum) are apparently unequaled. A string is in service after six years in a well where rods of SAE 4620 lasted about six to eight months. The "K" Monel rods were reported in excellent condition at the last inspection. The mechanical properties of "K" Monel, hot rolled and aged, are given in Table 4.

TABLE 4
Mechanical Properties of "K" Monel Sucker Rods (Hot Rolled and Aged Material)

Ultimate Tensile Strength	152,000 psi
Yield Strength	103,000 psi
Elongation in 8 inches	25.8 percent
Reduction in Area	43.5 percent
Endurance Limit (air)	44,500—58,000 psi

The writer wishes to express his appreciation to Mr. L. W. Vollmer, of the Gulf Research & Development Company, for figures 2, 3 and 4 and for his helpful comments on the general subject of corrosion fatigue.

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[3] Wescott, B. B., and Bowers, "Economical Selection of Sucker Rods," Trans. AIME, Vol. 114, 1935.

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[5] Jackson, L. R., Banta, H. M., and McMaster, R. C., Battelle Reports on Field Survey, "The Drilling Contractor," April 15, 1947, pages 42-47 concl. 55.

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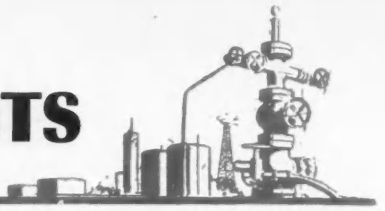

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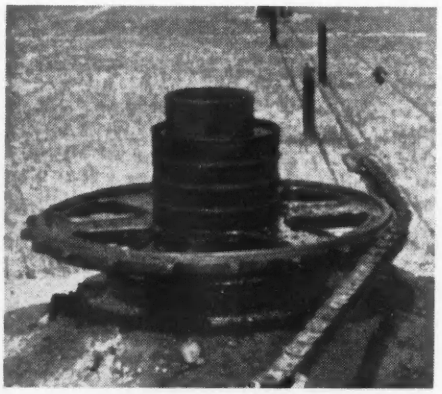
How To—Make Rod Line Swing from Discarded Sprocket and Chain

An ingenious pull rod swing for any angle up to 90 degrees can be constructed from discarded drawworks sprocket and chain as illustrated. Size of the sprocket and chain may vary somewhat, but construction is essentially the same.

A short length of shaft of the same diameter as that of the bore in the sprocket was mounted vertically in a concrete foundation, the height of which was such that the sprocket teeth are on the same level as the pull rods. A steel washer was cut from steel plating and slipped over the shaft before the sprocket was installed to form a thrust



bearing against the concrete. The sprocket was then set in place and held in position as shown by its own weight.

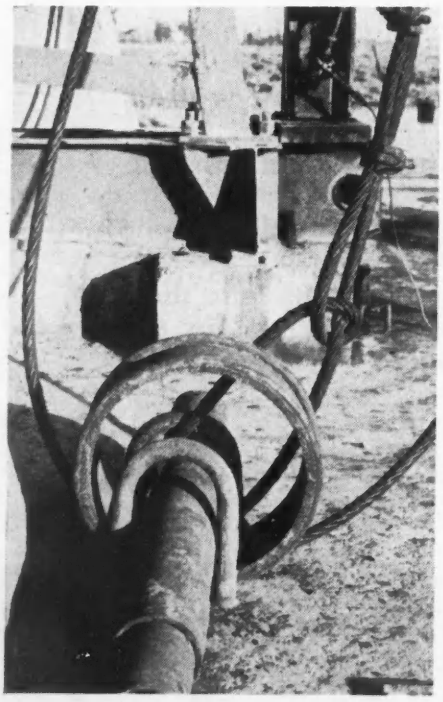
A cover made from half of an old grease drum provided protection to the bearing from rain water and dust. Lubrication is a simple matter in that only the cover need be removed to apply grease or heavy lubricating oil to the wearing surfaces. API number three chain and sprocket was used for lightly loaded rod lines, and number four chains and sprockets are recommended for heavily loaded installations. These units will withstand considerable loads under constant operation, and considering that salvaged material was used, cost was negligible.

How To—Reduce Stringing Up Time When Pulling Rods and Tubing

A frequent job in pumping wells is that of pulling the rods and tubing from the well. One producer employed a standard pumping derrick and pulling unit to do the job. Considerable time was saved in pulling both tubing and rods by a unique method of stringing the lines from crown block to traveling block.

Due to the additional weight of the tubing over that of the rods, it is many times necessary to string two more lines through the traveling block when preparing to pull the tubing after the rods are out. If the well is of medium depth, it may require two to four lines in pulling the rods and from four to six lines in pulling the tubing.

One producing company rigged an efficient dead line anchor which serves a dual purpose. It consists of two heavy "U" bolts firmly anchored in the concrete pad poured around the well, and was located adjacent to one of the derrick corner piers as shown. The "U" bolts were of such a size as to accommodate a short section of four-inch pipe, inside of which was inserted a longer section of three-inch pipe to serve as reinforcement.



The dead line was clamped to this anchor with wire rope clips and the tubing line strung alternately through the crown and traveling blocks. The first line to be threaded through the traveling block was returned to the dead line anchor and threaded under a short piece of 16-inch casing, to the edges of which were welded rod material thereby providing a rim. This rim prevented the line from creeping off the 16-inch casing. The line was then threaded through the crown and traveling block in the normal manner until a sufficient number of lines were provided. The first loop of the system being tied to the dead line anchor as shown, acted as the dead line anchor until the rods were pulled. When it came time to pull the tubing, the reinforced pipe was removed and the 16-inch casing taken out and the loop placed back into the traveling block where two more lines were thus added to the system. The large casing prevented crimping the wire rope, and the device resulted in added convenience and speeded the job.

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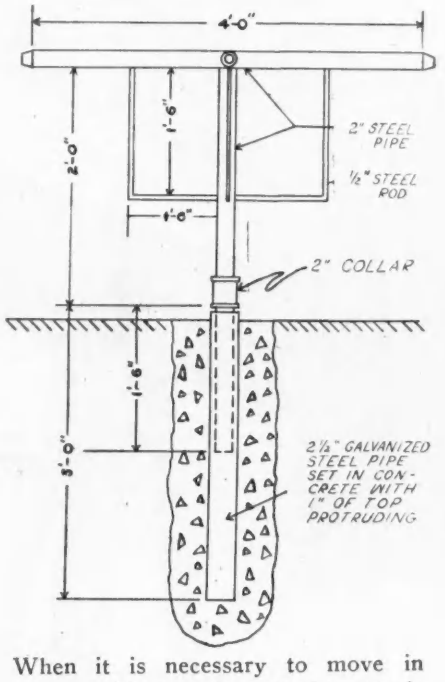
How To—Construct Improved Tank Battery Gate

At tank batteries where it is necessary to provide a fence and gate to keep out stock and unauthorized personnel, it is essential to install one that will cause the least amount of trouble, and one that may be removed easily when the need arises. Such a gate can be constructed from ½-inch steel rod, two-inch and 2½-inch galvanized pipe.

A cross is first made by welding pieces of 2-inch pipe which have been orange-peeled at the outer ends. A supporting nipple of two-inch pipe is then welded to the junction of the cross and perpendicular to the four arms. About 18 inches from the lower end of this supporting member, a collar is added to form a shoulder on which the turn gate may rotate. The half-inch rod is used to make additional guards below the cross-pieces as shown.

A section of 2½-inch pipe is then cemented in the ground leaving about one foot protruding above the surface. After the cement has hardened, the gate may be inserted into this footing. The shoulder provided by the two-inch collar acts as a stop bearing for the gate, permitting the gate to rotate inside the 2½-inch footing piece.

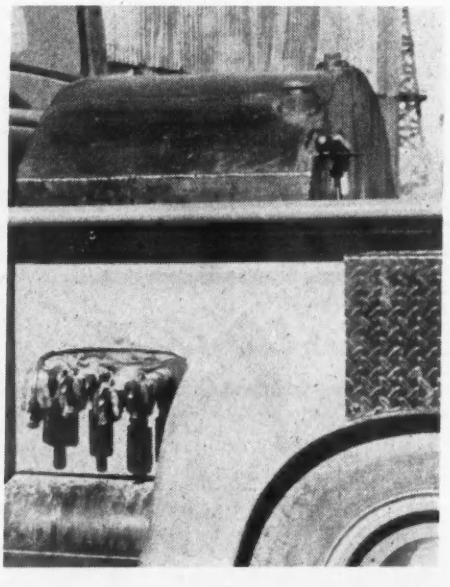


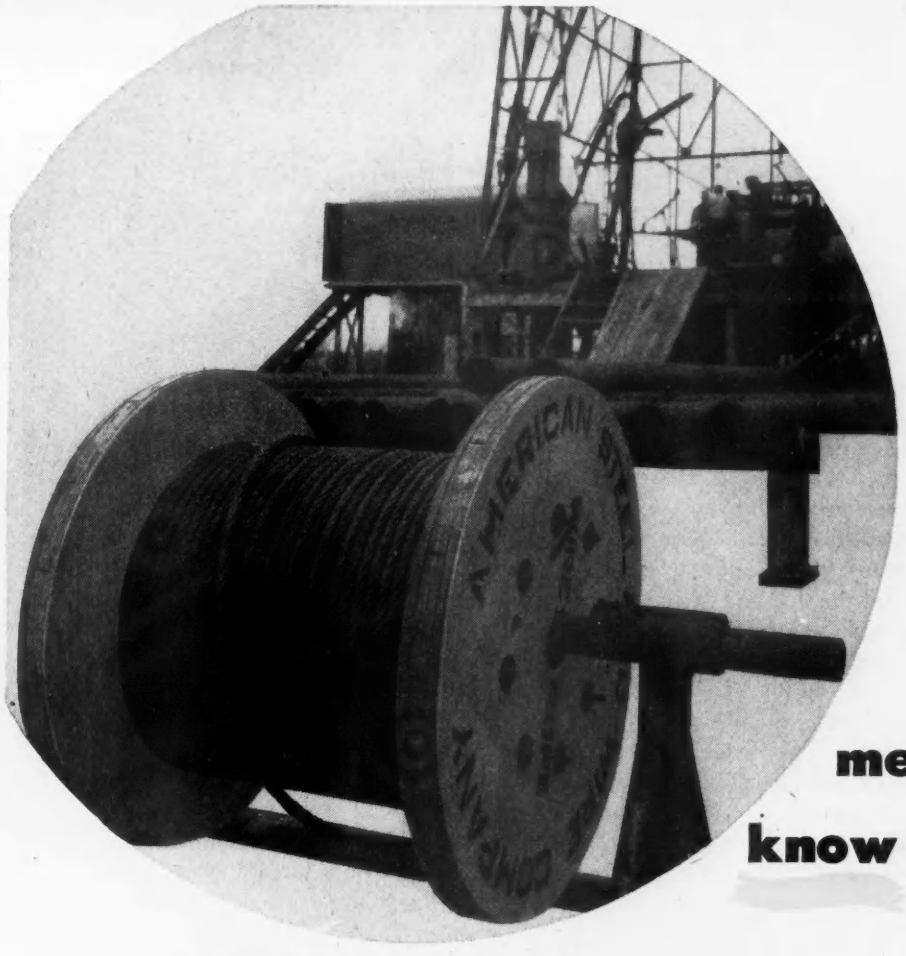
When it is necessary to move in pumps or other equipment, the gate is easily lifted from the footing, thereby clearing a wide opening into the battery. This type of gate eliminates the trouble of latching, unlatching and the possibility of leaving the gate open.

How To—Dispense Lubricating Oils From Truck

Pumping equipment of wells frequently are of different design and require a specific grade of lubricating oil which must be supplied at specified intervals. Other units in turn require, for example, a lighter SAE oil, and the pumper must be equipped to have these oils where they can be obtained with the least amount of time and with the least amount of spillage and waste.

One producing company supplies the pumper's pickup with an oil tank divided into four compartments so that any grade of oil required on the wells may be readily drawn into measuring cans. This oil tank is made with a flat base from which a separate withdrawal line is attached for each compartment and extend to one side through a slot in the pickup body where standard cutoff valves are connected. Three grades of oil are carried with the fourth compartment having cleaning solvent for removing oil and grease from machinery. The pickup is also fitted with a heavy steel step on the left rear fender so the pumper can step easily in the body without slipping and incidentally marring the finish of the truck.





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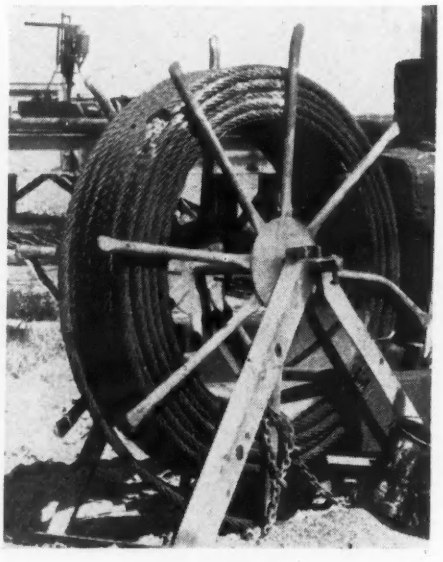
How To—Spool Tubing Wire Line

A tubing line which is to be used on different wells can be protected from damage and kept well greased when idle by spooling onto a reel. The reel is made of pipe and flat sheet metal, using one-inch pipe for spokes and separators between the two side wheels of the reel, and a round steel shaft for the axle. Sheet metal is placed over the spoke distance pieces so the wire line will lay flat against this support when beginning to wind the line on the reel. The shaft has a squared shoulder to accommodate a crank when winding so the reel can be rotated at the speed required for even spooling of the line.

A stand is made of angle iron with open bearings at the top in which the axle rotates. At the well, the stand supports the reel of wire line, but when stored in the production warehouse, the reel of line can be removed and laid flat on the floor to save space.

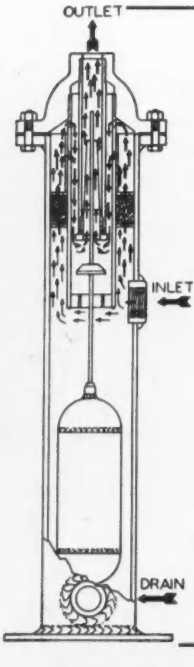


How To—Minimize Oil Losses at Lease Pumps

Oil which is released from pump cylinders in the course of priming the pump at the start of pumping operations was led through piping to a drum set in the ground near the manifold of the pipe line unit. This drum is also a receiver for drip oil passing through the packing glands of the stuffing boxes.

A two-inch line with check and gate valves was connected into the suction of the oil handling manifold so the pumper can easily pick up the waste by opening the one valve near the waste oil receiver.

Oil which otherwise would be wasted by spilling on the ground is recovered and pumped with fresh oil into the gathering system of the lease. At the present price of crude, only a short period of operation will be necessary to salvage enough fluid to pay for the material and installation.



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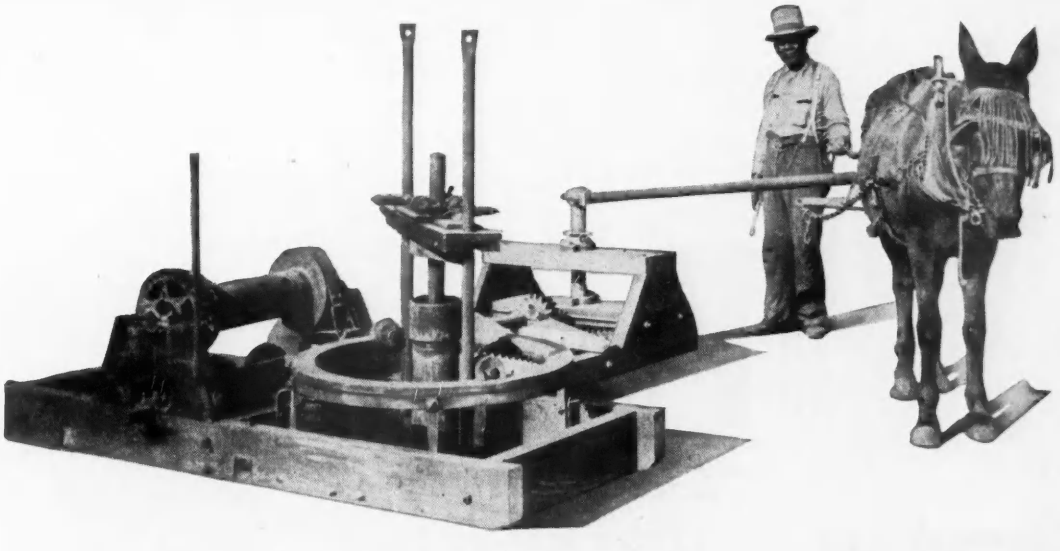

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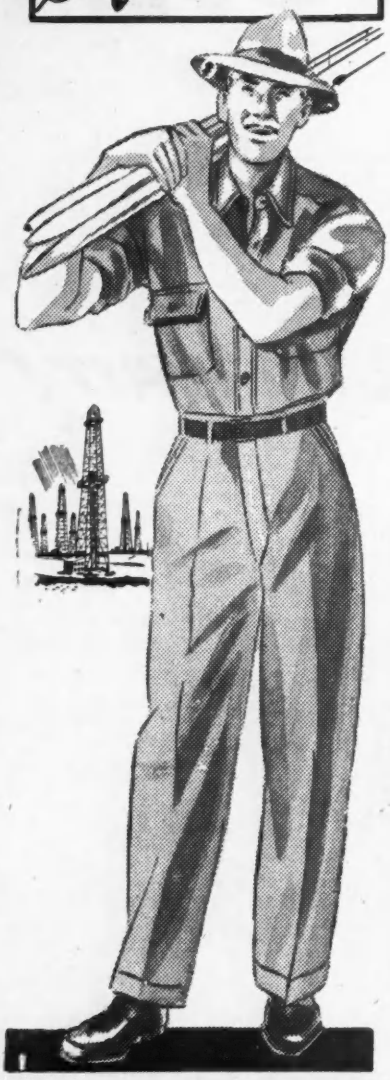

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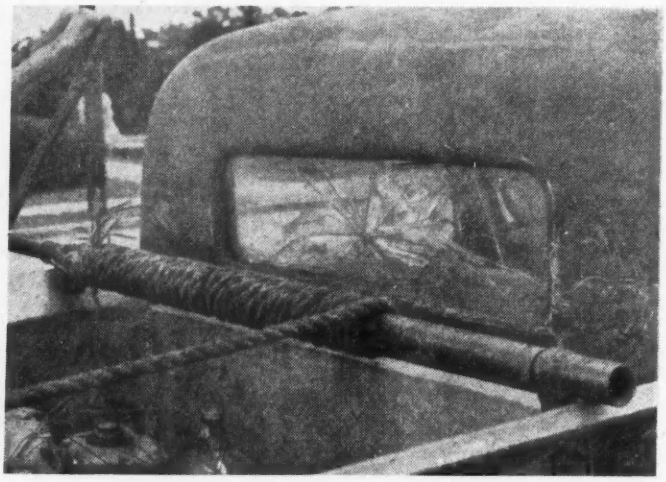
PRODUCTION HINTS

How To—Install Homemade Hand Winch



A great help in lease operations may be had by making up a hand winch from scraps of junk pipe. The bearings may be either installed on the top of stakes in a stake body and be made removable, or they may be bolted to the truck as shown. In this case, the "bearing" is made by sliding a two-inch nipple over a 1½-inch nipple which has been welded to the top of the stake. The crank side is made by using the two-inch as a bearing race and swedging down the two-inch drum to 1½-inch to pass through the bearing.

The crank is made from ¾-inch pipe which is slotted across the end and matched with a pin that passes through the end of the 1½-inch pipe used for a shaft.

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To eliminate the accumulation of rain water in the encased hole, a cover was made from plate steel just large enough to fully span the opening. It contained three guiding fingers which kept the cover on center. Two small holes drilled in the cover provided a means for lifting the plate.

Because the distance from the surface to the valve wheel was greater than the length of a man's arm, an extension had to be made. This is merely a ¾-inch steel rod approximately four feet in length connected to a section of 1½-inch pipe. Two opposing lugs were welded to this pipe as shown, and the ends turned down so they may be inserted in the valve wheel. A cross handle welded to the uper end of the stem provides the leverage necessary to open or close the valve. Two bracket hangers mounted on the concrete settling pit wall kept the valve extension out of the way and at a convenient location.

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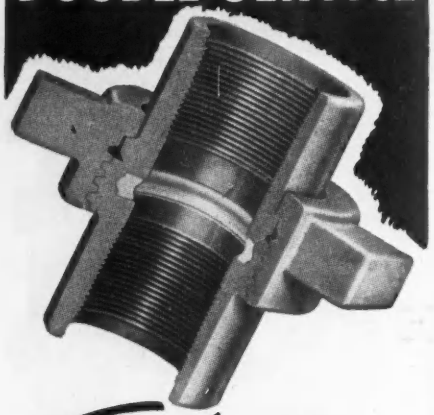

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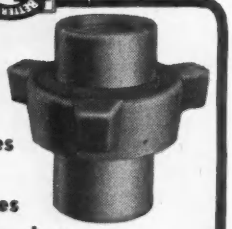

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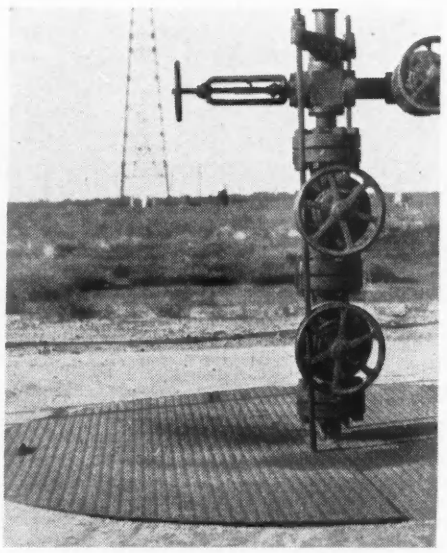
How To—Provide Permanent Cellar Covers

Many wells in old fields throughout the U. S. were drilled and completed by methods requiring a cellar below ground level to accommodate blowout control equipment and well head equipment. When it is considered that most of these wells will produce for a period of 15 years and upward, the desirability of a permanent cellar structure is readily apparent. If timber is used, the producer can naturally expect to replace the covering and possibly the encased walls several times during the life of the well.

Permanency was the keynote in the installation illustrated, which will eliminate all future work on the cellar. While it is much more expensive initially, other considerations are to the advantage of this type construction. Not only will it endure the life of the well, but it provides an absolute safe covering during the productive life of the well, requiring no attention or repairs.

In the case shown, the cellar was encased with concrete providing adequate space around the well head for workovers and inspections, and a wide surface flooring poured. A large circular groove was formed in the concrete base to accept a similar shaped piece of steel floor plating. The plating was cut in two sections with an overlap through the center for complete coverage. Two metal handles were welded to the plates to facilitate lifting and removing them for inspection or workover operations.



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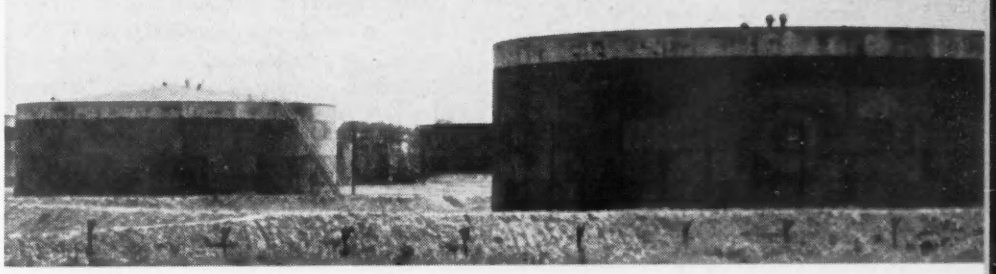
By M. H. PEARCE

Tank Tapping—

Valve Changing Without Purging

MAINTENANCE of valves, or the revision of tank-farm piping networks, sometimes requires the temporary withdrawal of a tank from service while the changes are made. The author here describes a few of the ingenious methods used by pipe liners to get the job done without taking the tank off the line, and without the tedious and expensive purging operations.



MAINTENANCE or revision of lines around the tank farm frequently calls for work on a tank which either must be kept working, or which can not be out of service for the length of time required for steaming out or purging by removing plates to insure complete clearing of the explosive or poisonous vapors left when the liquid contents of the unit are withdrawn.

Small taps can be attached to a tank plate by welding a flange to the outside wall of the tank, the flange being of the diameter of the desired outlet line. Welding is done by the arc method, using a small rod and running 1/16-inch beads until the weld is completed. Beads of that size, laid on by a careful welder, do not heat through the tank plate sufficiently to cause fire hazard within the tank. The welding should, however, be done when it is certain that there is a good head of liquid, not gas or air, above the spot where the welding is done.

After the flange is welded in place, any of the commercial tapping machines designed for tapping a pipe under pressure may be used to make the actual opening into the tank. This procedure involves the alignment of a nipple and valve on the flange before the tapping is done.

For large openings into a tank, much the same method can be used. Instead of the shank of the tapping machine being centered with the flange on the tank, the stuffing box is set at a point distant from the center of the flange equal to the diameter of the desired opening. The tapping machine is then used to drill a series of touching holes through the tank plate, rotating the nipple or fitting which carries the stuffing box through an angle or arc equal to the diameter of the hole drilled through the plate. If the job is well done, when the last hole is drilled the section cut off in this manner will fall into the tank, and lie on the bottom, out of the way of flow. The hole cut through the tank in this manner is serrated, and the time required is considerable. For instance, to cut a ten-inch circle in a tank plate, a minimum of 31 or 32 one-inch holes must be drilled and accurate rotating of the carrying disk is necessary if the plate is to be cut entirely through.

The superintendent of one tank farm used two-flange connections when cutting new 12-inch openings in the bottom rings of the "55's" for new suction lines. The flanges were to be bolted on, gaskets forming the seal between tank plate and flanges (Figure 1). On the inner flange, the one to be installed within the tank, the nuts were brazed in place, centered over the holes in the bolt circle. This flange also carried a bull plug, a cross of ¾-inch rod being welded within the center of the bulge to provide hold for a wrench.

Holes Drilled

While the tank was working, two holes corresponding to top and bottom bolts of the flange bolt circle were drilled through the plate, the same diameter as the bolt holes of the flanges. These holes were plugged with tapered wooden stoppers until time to place the inner flange. With the tank emptied to below the level of the new suction line, the tank was entered through the manhole and the prepared flange with bull plug also inserted. Working with life line and helmet, one man quickly found the spot for the new outlet, sighting on the two fingers of light entering through the two holes drilled previously, from which the wooden plugs had been knocked. Two studs, long enough to pass through both flange fittings, had previously been placed in the nuts brazed over two diametrically opposite bolt holes, and these were inserted through the openings already drilled through the plate. Two nuts, run up tightly on these two studs, held the inner and other flanges tightly in place, sealing the contact and maintaining alignment. On tanks having inside ladder and roof manhole, the entire job of placing the bull-plugged flange did not require more than three minutes' time and the entry of only one man, adequately safeguarded, into the tank.

With the two flanges aligned, the remaining holes in the bolt circle were drilled out from outside the tank, and bolts of the proper length screwed into the nuts positioned on the inner flange. After the flanges were thus positioned, any oil or explosive vapor within the bull plug was displaced by drilling two holes through the tank plate inside the flange circle, and circulating water or air until the desired safe condition had been attained. The tank plate was then cut out to give the desired opening, and the nipple and control gate placed on the outside of the tank while it continued in service with existing connections.

The gate placed, the bull plug was un-

screwed by a wrench of two-inch pipe, run through a stuffing box improvised from a union on a bushed-down fitting outside the valve. The inner end of the wrench was notched to engage the cross welded within the bull plug. With a pipe wrench on the outer end of the two-inch, the plug was backed from the flange, and dropped to the tank bottom. Where it was desired to retrieve the bull plug after unscrewing it, a wire line, attached to a swivel on the end of the plug, allowed it to be pulled up through the manhole.

Valve Changing

Changing gates or plug valves on tanks already in service can be accomplished in a number of ways without purging the tank or even pulling the fluid down to the level of the unit to be switched. One method involves the use of stoppers which, when pushed through the valve, are expanded to form a seal. Figure 2 shows a sketch of the device worked out for replacing a gate on a butane tank in the station fuel system. The fuel line was dismantled back to the damaged valve and the sleeve of 1½-inch pipe screwed into place. The rubber stopper, carried on the end of the ⅜-inch pipe, was then pushed inward until it had passed through the valve. Then, by turning on the ⅜-inch rod and holding the pipe against rotation, pressure was applied against the rubber sealing member by drawing the two flanges closer together. When a seal had been effected, the round nut at the outer end of the 1½-inch pipe and the packing behind it were removed, or slackened, so that the extension could be removed, leaving the seal and the ⅜-inch pipe assembly extending through the valve. The valve was then unscrewed without disturbing the seal, and a replacement installed.

By setting the extension pipe over the ⅜-inch rod, and reinstalling the packing assembly, the sealing device could be released without loss of fluid through the opening. Once the sealing member had been withdrawn past the valve body, that unit could be closed and the emergency device removed. If working with hydrocarbons, the rubber of the sealing device should be Neoprene or one of the other oil-resisting synthetics, to avoid possible dissolving of the seal by the fluid before the valve replacement had been completed.

Air bottles or plugs frequently are used to seal off the line behind a valve which is to be replaced. The bottles can be made from a section of truck tube, with the valve stem in an end, and the other doubled over and sealed by vulcanizing. A sack of loosely woven material, such as the linen mesh used for shipping onions or a salt sack, is slipped over the deflated sealing unit, and the ends reinforced with twine to withstand the air pressure at the ends. The bottle is placed with a basket or holder of ⅜-inch pipe, with fingers of copper wire to support the bottle. The valve stem is screwed into the end of the pipe or brazed there, and the unit inflated through the pipe. If the valve core is removed, a valve on the outer end of the pipe serves to hold the air within the bottle until it is desired to deflate it.

The air bottle is placed within a device such as that shown in Figure 2 and pushed through the opened gate or valve in its support at the end of the ⅜-inch pipe. When located, a little air is admitted to the bottle, and the holder oscillated or twisted slightly to be sure there is no fold or doubled-over section to impair the seal. Air pressure is then built up within the bottle to the desired value—usually from five to ten pounds above the hydrostatic pressure of the fluid within the tank—and the damaged valve removed.

When the replacement valve is set, the bottle is deflated. If an outside valve or petcock is used, deflation is simply a matter of releasing the pressure within the bottle. If the valve core is used to retain the air, a small rod is slipped within the ⅜-inch pipe until it contacts the protruding valve stem, when the air is released as when deflating a tire.

Inner Tube Used

Ordinary inner tube rubber may be used to form the bottle or stop, as it is easy to vulcanize and form the required end seals. But the solvent effect of hydrocarbons makes such a material dangerous to use when those liquids are to be held back during a valve change. Many of the synthetic truck tubes marketed today are sufficiently oil-resistant to make good material for the bottles, but the instructions for patching such tubes must be carefully followed and the unit given a pressure test before being used to block off liquids, as seemingly good jobs occasionally come loose, and serious results might follow were such to happen when the bottle was the only seal holding contents within a tank.

The usual bottle is made at least three times as long as the diameter of the pipe to be closed off, although this dimension must be governed by the length of the nipple between valve and tank facing. If the air bottle be too long, the end will extend into the tank, and the tank edge will tend to cut into the rubber; while any icicles or roughness left will puncture the relatively thin rubber and cause collapse of the plug.

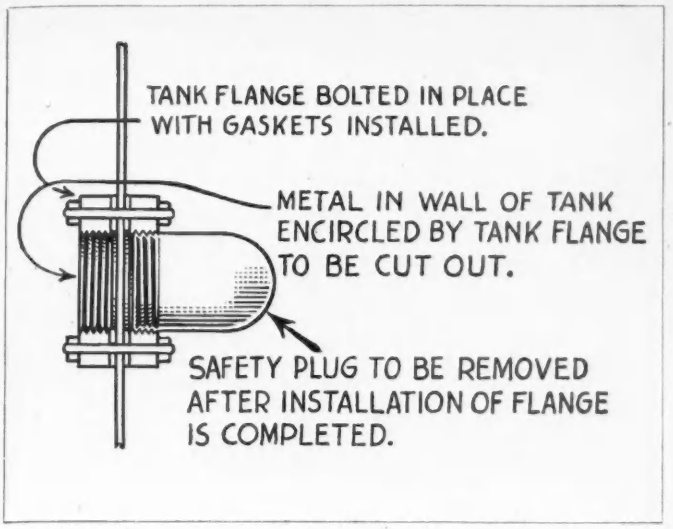
The air bottle, and to a lesser extent the method illustrated in Figure 2, can be used on plug valves or gate valves where the port is not the full diameter of the pipe on which it is carried. The seal shown in Figure 2 is limited by the width across of the retaining washers which face the rubber seal, while the air bottle is usable through relatively tight openings, the fingers on the inserting cage being bent to the proper clearance before the device is placed in the open end of the line.

Use of a flange-union stuffing box and extension lever or wrench permits pipeline seals such as shown in Figure 3 to be adapted to line closure behind a valve to be changed. The device consists of two steel disks, each slightly smaller than the diameter of the pipe in which they are to be used. Both disks are bored at their centers, with holes 1/16-inch larger than the outside thread diameter of the bolt used as binder. This bolt carries a long thread, this usually being cut until the dies contact the end of the eye in the bolt. On the outer side of one disk is welded a nut, another similar nut being welded to the thread on the shank bolt at a distance slightly more than the width of the unit and its rubber washers. The actual sealing members are rubber or Neoprene disks such as are used for driving pipe line scrapers. They are assembled in matching pairs, with the tapered edges contacting.

The device is placed in a short nipple of the same diameter as the tank line after this extension or sleeve has been attached to the outer face of the valve body. A stuffing box member, built up around a rod long enough to reach to the desired location of the plug, is made onto the pipe after the hooked end is engaged in the eye of the shank bolt. The hook is formed with a reverse curve, so that it will serve as pusher as well as puller. Using this rod as guide, the rubber sealing assembly is forced through the open gate and, once located, the rod is rotated to the right. This turning makes up the shank bolt in the nut welded to the farther disk, and the pressure thus set up between the two steel faces expands the rubber until a tight seal is effected against the pipe wall.

The seal made by this device is proof against relatively high pressures. Also, because of the separable connection between rod and eye of the shank bolt, the sealing portion left in the line during valve changing is entirely enclosed in the nipple between valve and tank wall, and is in no danger of being dislodged while valves are being shifted.

Where the inside face of the tank plate at the opening has been reamed or if a short pipe nipple is used on the flange within the tank, the device sometimes used to prevent air from entering the delivery line can be adapted to pipe line service. This involves the use of a wooden ball slightly larger in diameter than the pipe to be plugged. A rubber or synthetic ball of the proper size, if resistant to hydrocarbons, may be used, if


TANK FLANGE BOLTED IN PLACE
WITH GASKETS INSTALLED.
METAL IN WALL OF TANK
ENCIRCLED BY TANK FLANGE
TO BE CUT OUT.
SAFETY PLUG TO BE REMOVED
AFTER INSTALLATION OF FLANGE
IS COMPLETED.

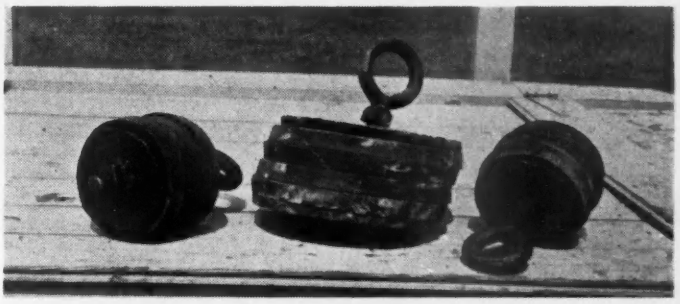


FIGURE 1 (left). Method of bolting flange and bull plug inside tank to allow portion to be cut out for new connection. Only two holes are drilled before the companion flanges are placed, additional holes being drilled and bolts placed without need for entering tank or venting same.

FIGURE 3 (right). Two 6- and one 10-inch expandable sealing units for closing off pipe lines or providing blinds for gate changing or maintenance. Fixed nut on one disk and stop nut on threaded shank of eye bolt provide means for expanding rubber disks against wall of pipe.

the buoyancy can be adjusted so that the ball will not float too high in the liquid within the tank.

To seal the outlet, the ball is placed in the tank, and allowed to float on the surface of the liquid. As the fluid is drawn out, the ball tends to gravitate toward the center of the discharge cone, and to be in the center of the cone which forms at the outlet just before suction tends to break. Flow of the fluid will carry the ball with considerable force into the outlet opening. There, if the aperture be smoothly faced, the ball will seal off as effectively as would a check valve. After flow ceases, the fluid in the tank levels off, with a slight head behind the ball to hold it in place. If fluid then can be added to that in the tank through a pipe other than the one against which the ball has been floated, still more head can be built up on one side of the ball, pressing it firmly into the pipe opening.

With the ball in place, the effectiveness of the seal may be tested by cracking open the valve, after the pipe line has been stripped back to the gate valve body. The drainage of fluid trapped behind the valve—if it has been closed following floating of the ball into place—should not be mistaken for seepage past the sealing device.

Additional protection for the tank contents may be secured by fitting a collar with bull plug and screwing this assembly lightly in place when the valve body is removed from the tank. If this protection is used, however, provision must be made to vent air from within the plug. In one instance when such a cover was placed, the air within the nipple was slightly compressed as the cover was screwed into place. Hot sun on the nipple, its contents of air insulated from the relatively cool liquid within the tank, caused the air to expand further, pushing out the sealing ball and allowing tank liquid to flow again into the line. It was necessary to pump down the tank through the two-inch water drain line before the cover could be removed and the valve replaced.

One or more of the methods described may be adapted to almost any tank tapping or valve replacement problem; they are all field- or tank farm-proven, and require little in the way of special equipment. Where they require especial care in installation, that care is repaid many times over by the time and expense saved over the method of draining and cleaning or purging a tank before proceeding with the necessary work.

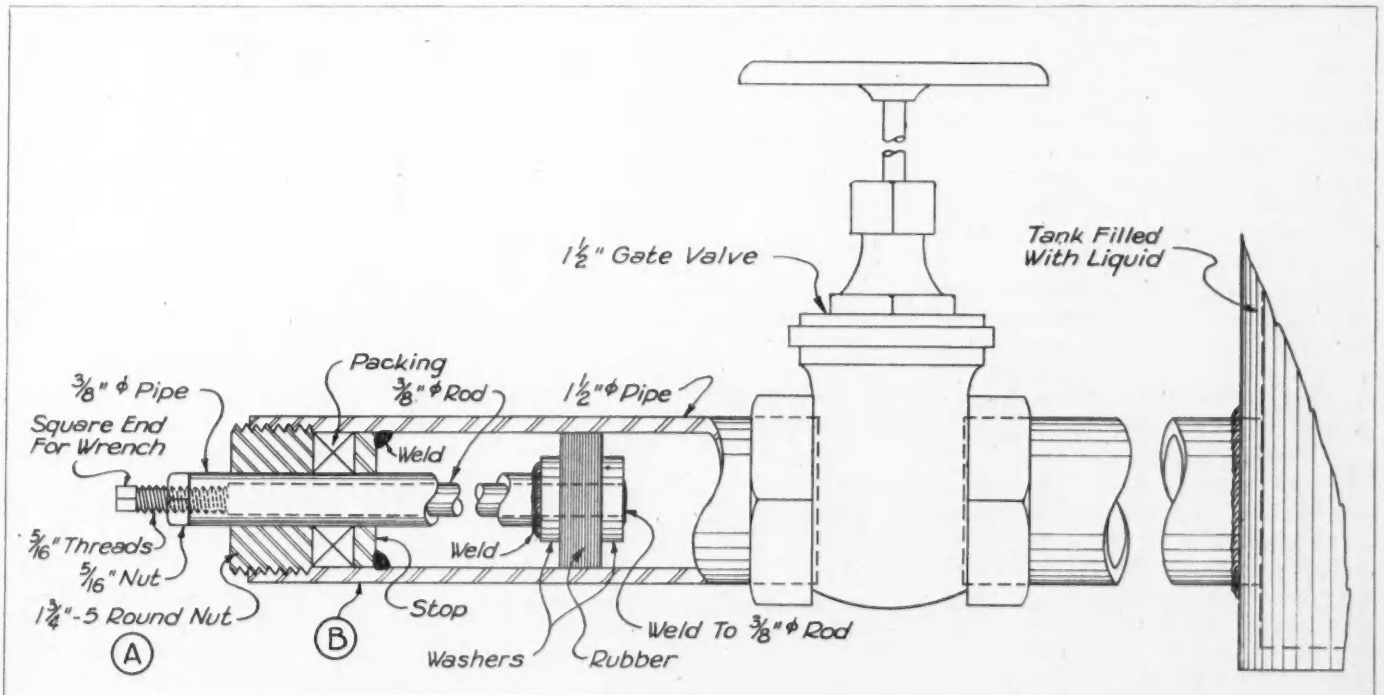
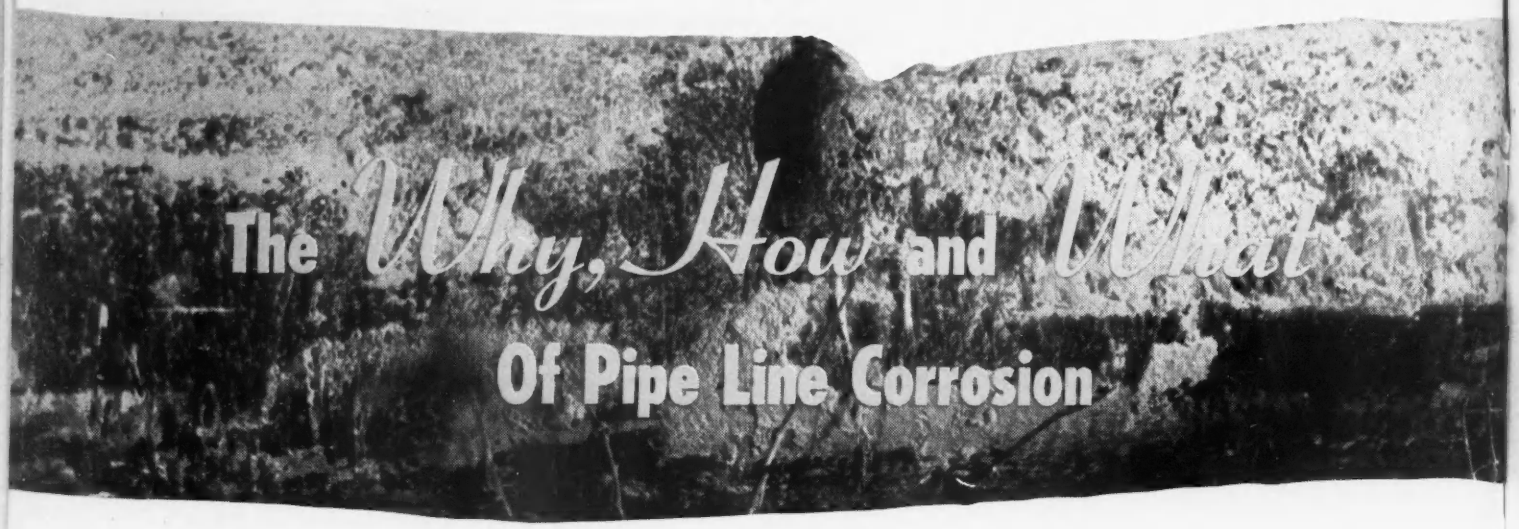


FIGURE 2—Detailed sketch of plugging hookup to blank off tank pipe connection and allow valve to be removed and replaced regardless of level of liquid within tank. Proportions shown for 1½-inch pipe are used for larger lines, with exception of rubber closure. On larger pipe the closure is contained in swage of valve diameter at large end.



The Why, How and What Of Pipe Line Corrosion

By M. E. PARKER, JR.
Corrosion Engineer, Pan American Pipe Line Company

EVERYTHING that man makes is subject to the destruction by nature. His houses and his cities, his toys and his tools, constantly are attacked by wind and weather, by rot and rust. Sometimes the attack is by the swift and violent earthquake or storm; again it is by the slow and stealthy termite or corrosion. But always it is there, and always he must battle against it, with all the means at his disposal, including the forces of Nature he is able to turn to his own account.

Of all the materials man uses, the most durable are those he finds in Nature and uses unchanged, like granite, slate and gold. The most perishable are those he wrests from Nature with difficulty, like iron and steel and magnesium. Some, like phosphorus and sodium and lithium, are so extremely unstable that they have to be protected with great care in order to preserve them in the pure states, and are of no use at all in any kind of building or construction.

The iron and steel we use for pipe lines are materials not found in nature. The metal must be extracted from its ore, and in that process great quantities of energy, in the form of heat, are expended. The finished product, having more energy than the raw material of Nature, is thus an "elevated" substance, and will seize the first good opportunity to run downhill, or degenerate toward its original, primitive form. Metals like gold and platinum and copper, all of which are found in the metallic state, are much less apt to corrode under most conditions. The metals can, in fact, be arranged in a series which shows their relative energy level. For purposes of convenience, this energy level is usually measured in volts; that is, in electrical energy units, rather than those of heat. For this reason it is usually known as the "Electromotive Series of Metals."

WHY do pipe lines corrode? Because iron and steel are hard to make; because hydrogen acts like a metal; and because there is water nearly everywhere.

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WHAT can we do about it? We can stop these circulating currents. No currents, no corrosion—but stopping them is not always easy or cheap.

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Calcium	2.87 volts
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Tin	0.14 volts
Lead	0.12 volts
Hydrogen	0.00 volts
Antimony	—0.10 volts
Copper	—0.34 volts
Silver	—0.80 volts
Mercury	—0.80 volts
Platinum	—0.86 volts
Gold	—1.36 volts

This is not a complete list; all of the other metals belong somewhere in the series, although some of the rare ones have not been accurately located. Moreover, some of those listed actually should appear in two different locations; this variation being determined by the kind of solutions in which they are exposed. Hydrogen is included because chemically, and especially in electrochemical reactions, it behaves like a metal, although physically it is a gas. All of the voltages shown are measured with respect to hydrogen, which occupies a very important and fundamental position in the series.

The metals above hydrogen are almost never found free in nature; the higher they stand in the series, the more energy is required to free them from their compounds, and the more readily they go back into combination. The top three react violently with water, while lithium, at the top of the list, will react rapidly with air unless it is absolutely dry.

At the other end of the series, below hydrogen, are metals which are frequently found in the free or uncombined state. At the bottom of the list is gold, which is seldom found except as dust, grains, or nuggets of almost pure metallic gold. These metals are all comparatively stable, and will remain unharmed in a variety of conditions. The reason that hydrogen, instead of one of the other "metals" is used as the reference point and stands at the division point of the series, is that hydrogen is the "metallic" part of water, and water is the necessary ingredient for almost all chemical reactions. This is an important fact that is frequently overlooked—even by chemists; there are few chemical reactions that are possible without the

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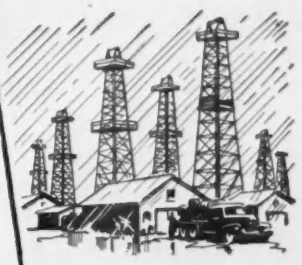

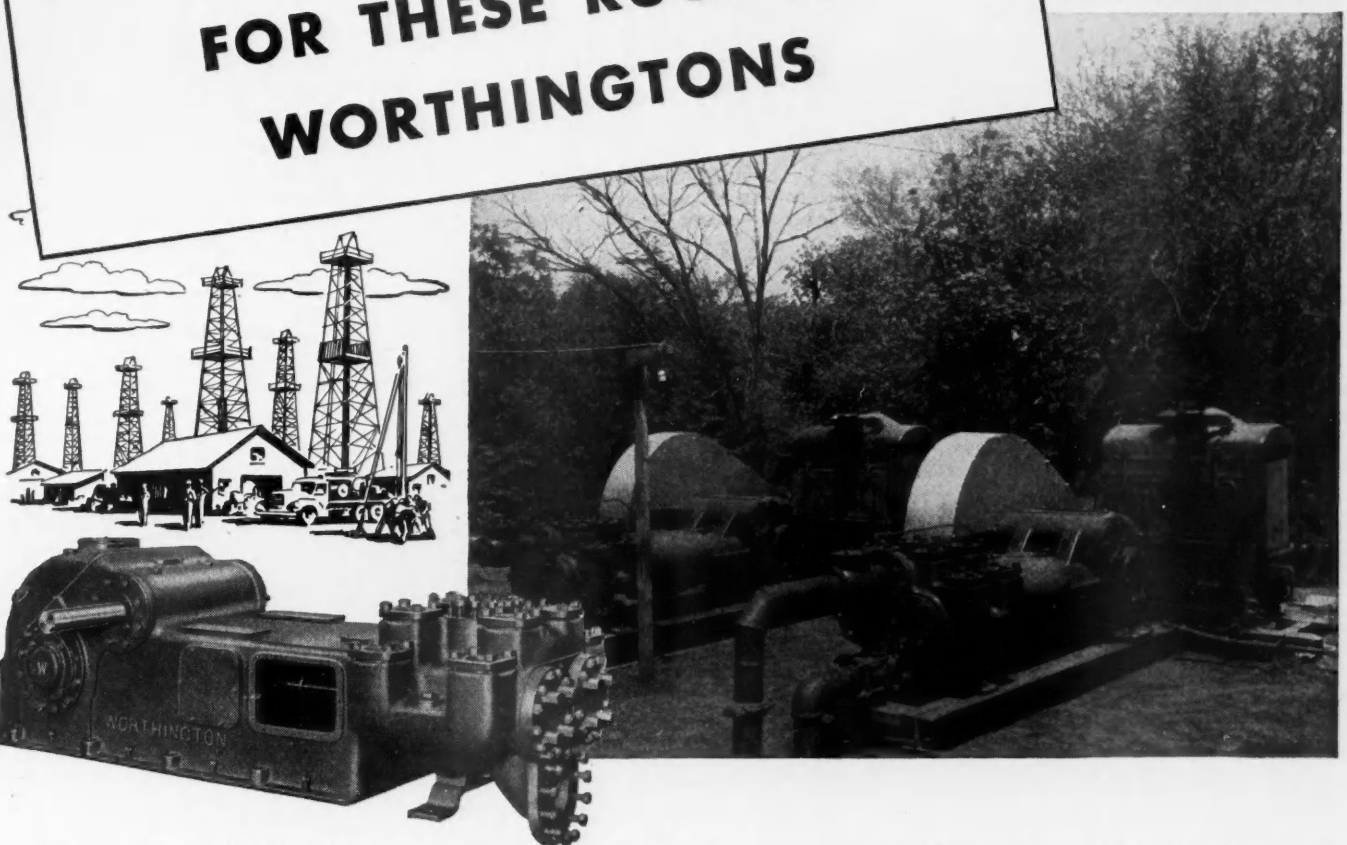

You can install Worthington Horizontal Duplex Power Pumps out in the open and forget pumping worries. Year after year, in good weather and bad, these tough, tireless performers are taking the roughest usage . . . coming back for more . . . and proving themselves unbeatable for efficient, economical oil gathering, pipeline, transfer and loading services. That's assured by thorough factory-testing before shipment.

More Sizes Than Any Other Line

Worthington Duplex Horizontal Power Pumps are made in 50 sizes, 2½" x 4" to 7½" x 12", providing the *right* pump for requirements up to 16,500 barrels a day and 1500 psi. And you'll find complete stocks at key points throughout the oil fields. For further facts proving *there's more worth in Worthington*, write to *Worthington Pump and Machinery Corporation, Reciprocating Pump Division, Harrison, New Jersey.*

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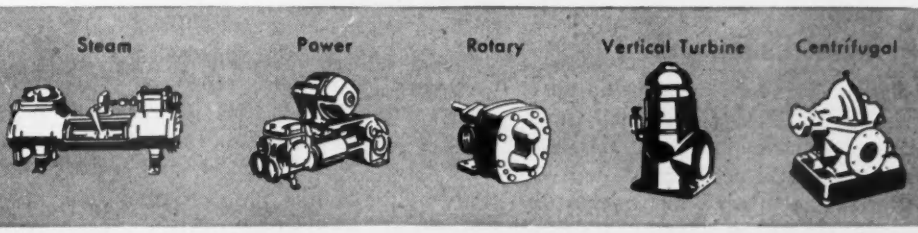
Totally enclosed, dust-proof, oil-tight power end . . . Roller bearings . . . Herringbone gears . . . Cast steel crankshaft and connecting rods . . . Flood lubrication . . . Cast iron, one-piece, eight-pot-type liquid end . . . Each valve in separate pot for easy accessibility . . . Unbreakable, drop-forged valve pot covers . . . Removable liners . . . Deep stuffing boxes . . . Cup-type pistons.

WORTHINGTON

P7-6

THE WORLD'S LARGEST MANUFACTURER OF PUMPS



Pipe which has been reduced by corrosion to the extent of this threaded main line is a total loss. Of the original 0.25 inch wall, nothing but a thin plate of rust remains over large areas, and much of the pipe buckled of its own weight when picked up.

Laid through a "hot spot," this natural gas trunk line had all but returned to the native state of iron oxide before it was dug up for replacement with properly coated and protected pipe.

presence of at least a trace of water. Just as the sea is the original source of life, and water is a part and a necessity for all living things, so is it an essential for all chemical activity.

And there is water everywhere. The dryest soils contain from 3 to 10 percent water; the moisture content of the air is never quite zero; water is in the pores of the densest rocks, and thin films of it cling to apparently dry surfaces—even at temperatures above its boiling point. It is a part of all living things; it is locked up in most crystals.

When any metal is in a solution which also contains a compound of a second metal lying further down in the series, the higher metal will dissolve into the solution, replacing the lower one. Thus if we place an iron nail in a solution of copper sulfate, the iron will be dissolved, and metallic copper will be deposited. In this respect, water acts like a solution of a hydrogen compound. When any metal in the upper part of the series comes in contact with water, it starts dissolving, and hydrogen comes out of solution. What happens next depends on a number of things. The process may be arrested by the formation of a protective film of some sort—but it always starts. Therefore, any metal lying above hydrogen is in danger of being corroded when it contacts water, and it must be protected by some means, natural or artificial, all because it lies on a high energy level.

So long as we make our pipes of iron and its alloys, they will try to degenerate to their primitive compounds—to run back down the energy hill up which they were dragged in the process of refining the ore.

How Pipe Lines Corrode

Pipe lines corrode by setting up batteries in the soil—large and small—and circulating electric currents through themselves and the soil. What does it take to make a battery? Two pieces of metal, connected electrically, and immersed in a solution of something in water. Almost any kind of metals will do [and some other substances, like carbon] and almost anything dissolved in any quantity of water. One other thing is essential—there must be a difference between the two "electrodes." They may be made of two different metals or alloys; they may be placed in the solution so that one is in a more concentrated solution than the other; they may be at different temperatures; one may be in a drier location than the other; or one may get more air than the other. Any of these differences is enough to form an "electrolytic cell" and start current flowing.

The important thing for us is that one of these electrodes will be corroded or eaten away by the process. This is the one called the "anode" and is the one from which current flows to the solution. The other one, to which current flows from the solution, is called the "cathode" and is not damaged by the process.

If the electrodes are two of the metals shown in the electromotive series, the one higher up will be the anode, and will be corroded, while the lower one in the series will become the cathode, and will escape damage. Thus, if a piece of iron and a piece of copper are placed in a solution, in good electrical contact, the iron will be anodic, and will be corroded, while the cathodic copper is unharmed. If zinc and iron are used the zinc will be the anode; the iron will be cathodic, and thus will escape damage. It may be said that the iron is "protected" by the zinc. This is what can happen if a piece of galvanized pipe is attached to a piece of plain iron pipe and the two buried in the soil. The current flows through the soil from zinc to iron, and the circuit is completed through the pipe itself. The same result can be obtained by screwing together two pieces of galvanized pipe. Where the threads are cut, and where there are tool marks, the zinc is removed and raw iron exposed. Since the anodic [corroding] area of the zinc is so much larger than the cathodic [protected] area of the iron, the actual damage done is slight. If the situation were reversed—say by using a copper plated pipe—then the corrosion would be concentrated on the small areas where the plating was damaged, and very soon there would be leaks.

The same thing occurs when copper pipe is connected to iron pipe and both buried in the soil. This is a risky combination, although frequently the area of the iron is so large that the damage is widely spread and no perforation occurs.

How Pipe Lines Corrode

But what of pipe lines? Here there are no combinations of unlike metals to form these batteries. But there are differences in other respects. If a line of absolutely pure iron (perfectly clean) were buried in a soil perfectly uniform in all respects—composition, porosity, moisture content, temperature, depth, and a hundred other factors—then theoretically it would escape corrosion. Actually, such a thing is impossible. The pipe surface has mill scale of varying composition and thickness. At places it has been cut, scratched, or otherwise damaged in handling. Steel is not of perfectly uniform composition; and the welds cannot be exactly the same as the pipe. The soil itself varies tremendously in all the factors named above, and many more.

As a result, when a bare line is buried, a multitude of batteries start working immediately. Some are small, set up by the metallic differences around a scar or dent, or by mill scale. Others are larger, set up by differences in soil composition. There will be hills and valleys, with varying degrees of wetness. There will be, in short, an innumerable collection of differences setting up batteries vary-

One of the Halliburton Oil Well Cementing Co.'s new service boats. Once wartime LCT's, these boats are propelled by marine conversions of GM Series 71 Diesel engines.

With a draft of only 3½ feet, the service boats can move in alongside wells located in Louisiana's many marsh regions.

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Here is special Halliburton Oil Well Cementing service for Gulf Coast drilling operations—the first self-propelled craft ever equipped to do this important job.

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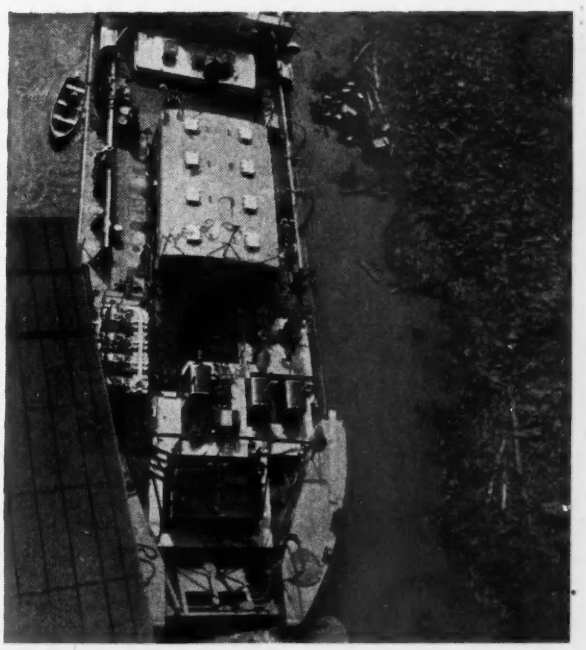
All three of these boats are completely powered by GM Series 71 Diesel engines—for propulsion and pumping.

GM Diesels are two-cycle with power at every downstroke, so they are small in size and low in weight for the great power they produce. All through the oil industry they are proving that they are the Diesels ready to do any job well.



The deck view shows the high-pressure pumps and the GM Series 71 Diesels that drive them. Each boat carries 2,000 sacks of bulk cement.

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ing from an inch between electrodes to several miles.

Some of these will oppose others; some will reinforce. All of the locations where current is leaving the pipe are anodes, or anodic areas, and at all of them there will be destruction of metal. Those areas at which current is entering the pipe are cathodic, and no damage is being done there. As time passes, various chemical changes are taking place in the soil next to the pipe at these locations, both anodic and cathodic. At the surface of the metal itself things are happening. Some of these changes have the effect of partially blocking the currents, decreasing the flow, and thus slowing the rate of corrosion. Some of the areas that were originally anodic may become neutral, then cathodic. The reverse change is far less likely to occur. Since the anodic areas are the ones at which the damage occurs, this would seem to be an advantage. It is, so far as total metal loss is concerned. Unfortunately, however, the remaining anodes discharge more and more current, and the metal loss through them is faster and faster.

All of this takes place silently and invisibly. It is brought to the attention when the loss at the most severely anodic point is great enough to penetrate the pipe wall, with a leak as the result. Then when it is dug out for repair, it may or may not have other pits nearby, but almost always many square feet of pipe are found in excellent condition. This was the cathodic area. When the situation is bad enough to eat a hole all the way through a pipe wall, there will always be found a lot of undamaged pipe nearby; there can't be anodes without cathodes, and it takes a lot of cathodic area to produce a really bad anodic point.

If the pipe is coated, the situation is not very different in principle. The location of anodic and cathodic points will be limited to those points at which moisture reaches the pipe surface through breaks or defects in the coating. Between any two such points there usually will be enough difference of some kind to cause a flow of current; eventually, a few of these points will become permanently anodic, and pitting will result. It will not be nearly as extensive as on bare pipe, and it will take longer, but it is inevitable in sufficiently corrosive soil.

Some soils are a great deal more corrosive than others, and this is not too easy to determine in advance. Among the factors which enter into this are the kind and amount of dissolved chemicals, the acidity, moisture content, porosity to air, and a host of others. One characteristic, however, is of prime importance—the electrical resistance of the soil. Since the soil forms a part of the circuit through which the corroding current flows, it is obvious that, other things being equal, a soil which is a good conductor of electricity will be more corrosive than one which is a very poor conductor. Also, very low resistance is a good sign of the presence of large quantities of dissolved chemicals.

This is amply borne out by experience. The following rule of thumb is pretty accurate: soils whose resistivity is below 1000 ohm/cm are almost always corrosive; soils above 10,000 almost never; while those in the range from 1000 to 10,000 may vary from very corrosive to very mild, depending on some of the many other possible factors.

When a pipe is put in the ground, then, as soon as the moisture gets to it, the inevitable differences start a set of batteries working; when these have worked long enough, there are holes in the pipe. What can be done about it?

What Can be Done About Pipe Corrosion?

What can be done, now that the why and how of pipe corrosion are known? The answer is easy to state, and not too difficult to accomplish. To arrest corrosion, it is necessary only to prevent any current from flowing from the pipe to the soil, anywhere along the full length of the lines. It is absolutely certain that this will stop most corrosion; it is highly probable that it will stop all corrosion.

There are two possible methods of doing this; one is to place a barrier between the pipe and the soil moisture through which the current cannot pass; the other is to overpower the natural batteries with stronger voltages from an outside source of power, and thus force the current to flow the other way. It works out in practice that the first, or barrier method, is never quite attainable. Our barriers, although very good indeed, are not quite perfect. The second method, using outside power, is in many cases too expensive. The very best solution now known is a proper combination of these two.

It has been seen that water is an absolute necessity for corrosion; there can be no battery action, no flow of current, unless there is water in contact with the pipe. This is the first requirement for coating. Before it is even worth considering, it must be waterproof. It must also have a number of other properties—it must be something that can be put on pipe, and which will stay on pipe, under very trying conditions. The pipe moves about as its temperature changes; soils shrink and swell, and try to squeeze the coating off the pipe; the moisture, and all sorts of chemicals, are in the soil, ready to attack and destroy; all manner of insect, animal, and vegetable life is present and viciously active—not to speak of bacteria, fungi, molds of all kinds, and man—with his plows and road graders. Then, too, this material is something needed by the carload and the trainload, so it must be plentiful and fairly cheap.

There are a number of materials that almost fill these requirements. At least they look like they do, in the laboratory. But on the line, in spite of all care, there are always a few places where water gets to the pipe. The most careful inspection, with elaborate instruments and good inspectors, may succeed in starting a perfect coating job down into the ditch. By the time all the pipe is lowered, it has received some wounds. When it is backfilled, it gets some more. Then, as the months go by, and the seasons change, other breaks and injuries occur. So, in the long run, the very best coating now known, applied by the most expert and careful workmen, using the best equipment, is not quite good enough.

Cathodic Protection

The other method of stopping the currents is to overpower them with an outside voltage stronger than that developed by pipe-soil batteries, so that at no point is there any current flowing from the pipe to the soil. In order to do this, it is necessary to supply enough current so that everywhere there is a flow from the soil to the pipe. Electric currents can flow only in closed circuits, so all the current the pipe is collecting has to be drained off through one or more wires or cables connected to the pipe. (Current leaving the pipe in this way, through a solid metallic connection, does no damage). This current is then led off to some point and put back into the soil, thus completing the circuit.

The effect of this arrangement is to make all of the pipe act as a cathode—hence it is called cathodic protection. The terminal through which the current reenters the soil must then be the anode—and if it is of metal, it will be consumed in the process and must be replaced eventually.

The source of power to be used has not yet been identified. Something must force the current to flow in the desired direction, and this will require the expenditure of energy in some form. Generally speaking, any source of direct current may be used—and most of the known sources have been tried at one time or another. It is possible to use a motor-driven generator; a windmill generator; a rectifier, converting alternating current into direct; or one of the many forms of a battery. All of the above require an anode or anodes, which are usually made of junk iron or steel, or of some form of carbon. Iron or steel

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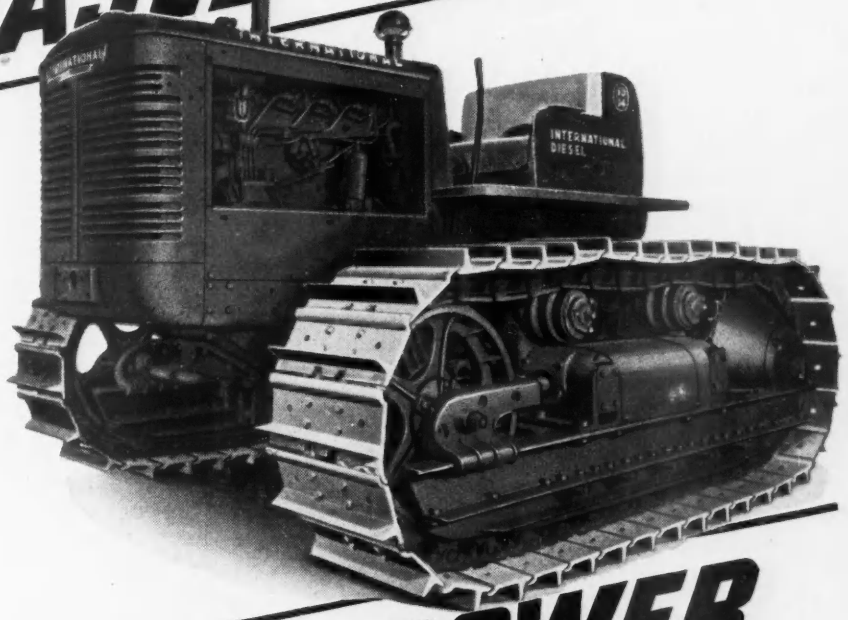

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anodes are consumed in the process; carbon anodes, more expensive initially, are either consumed very slowly or not at all.

It has been seen that the mere exposure of steel pipe to varying soils causes batteries to be set up, with the resultant current flow consuming the pipe in some spots and protecting it in others. It has been frequently suggested by those interested in the problem that, if this is true, sections of bare junk pipe or scrap metal should be attached at the right places, and let them be the anodic sections, and thus protect the pipe that is carrying the oil or gas. This sounds like a good idea, but it has its drawbacks. The "right places" cannot be located accurately enough, and all those little differences that cause batteries cannot be controlled well enough to make the current flow exactly where it is desired. Now, if this scheme is modified a little bit, it really works.

Look back at the Electromotive Series. Instead of using a piece of junk pipe, and hoping it will become an anode, use a piece of some metal above iron in the series, and know it will be an anode. Of all the metals above iron (including some rare ones not listed) there are three that are cheap enough and well-behaved enough to consider. They are zinc, aluminum, and magnesium. If a piece of one of these metals is connected electrically to the pipe and buried in the ground alongside, it should be anodic to the steel, and thus make the pipe cathodic for a portion of its length. Actually, all three of these metals have been used in this way. Zinc was the first one tried (at a time when the other two were still too expensive.) It has protected a lot of pipe in a lot of places. However, zinc is a little too close to iron in the series, and will not always produce enough voltage for protection. Magnesium has been used widely, and its use is growing. When it was first tried, a great deal more magnesium was consumed than should have been, according to the current output; in other words, the "current efficiency" was very low. This has been partly overcome by using a special chemical backfill around the magnesium. Aluminum, unfortunately, is a metal which forms an insulating film on its surface when it is made anodic. It starts out well, but in a short while it "polarizes", the current drops off to nearly zero, and it just sits there. This is being studied intensively, and it is quite probable that the right kind of a chemical backfill will overcome this difficulty in time.

When generators or rectifiers are used for power, corrosion from the pipe is transferred to iron or carbon anodes. The corrosion of these anodes is not very important, since they are of relatively cheap materials. But a power or fuel bill must be paid each month for the operation of the rectifier or generator. When "sacrificial" anodes of zinc or magnesium (or aluminum; give the research men a little time) are used, there is no power bill to pay, but the corrosion is now transferred to a metal more expensive than the steel of the pipe lines. However, the result of the loss by corrosion of one pound of magnesium is just one pound of magnesium, plus the cost of installing it; the result of the loss by corrosion of one ounce of pipe steel may be fifty barrels of oil, a six-hour shutdown, a $200 repair charge, and a damage claim from a property owner; or it may be a lot more, even involving the loss of life in a major disaster.

So there are two methods for stopping the flow of current from pipe to soil—waterproof coatings and cathodic protection. Both cost money, and for both the cost increases with the degree of protection afforded. In the case of coating, no matter how much is spent on it, it is impossible to get—and keep—a perfect coating throughout the length of a pipe line. In the case of cathodic protection, it is possible to get complete protection, but the cost, under the worst conditions, is prohibitive. However, even a poor coating will cover a lot of pipe, and thus reduce the cost of cathodically protecting the remainder. Using all that is known about coatings and cathodic protection; utilizing all the products, equipment, and methods, it can be said that for a new line, the very best solution will be a good coating (not necessarily the best) and cathodic protection to take care of the few defects in the coating. Strike an economic balance, and find out where to put each dollar in order to get the maximum return.

Every line will be an engineering problem in itself; the answers are not all alike. But, unless we are building for a very short life (and a low salvage value) or unless we are in an extremely favorable location as to soil corrosivity, the answer will almost always be a division of dollars between coating and cathodic protection.

A bare line must be protected over 100 percent of its area; the cathodic cost is a maximum. A very poor coating, very poorly applied, may result in a line 20 percent bare when laid, and 50 percent bare when a few years old. For such a line, the cathodic costs would be one-fifth initially, and one-half eventually, of those for a bare line. By using a somewhat better coating, and taking some pains in its application, it is easy to get a line 2 percent bare when laid, and 10 percent bare eventually. Now we are beginning to get some real dividends from coating expenditures. Cathodic protection on this line will be one-fiftieth at first, one-tenth later, as compared with the same line with no coating. (These fractions refer to the current required; translated into dollars they will be slightly higher, since spreading the current thinner makes it cost a little bit more per unit; say one-fortieth and one-eighth.)

If considerably more time is spent on the coating—using better materials and a great deal more care in its application—it is possible to get up to ½ of 1 percent bare at first, 2 percent bare after several years. To do this will not cost as much as the cathodic savings. We are still making money. But the limit is near.

No matter how much is spent on coating, there is only that 2 percent left to save. We cannot afford, under any circumstances, to spend additional money on coating in excess of the cost of cathodically protecting that 2 percent of bare pipe.

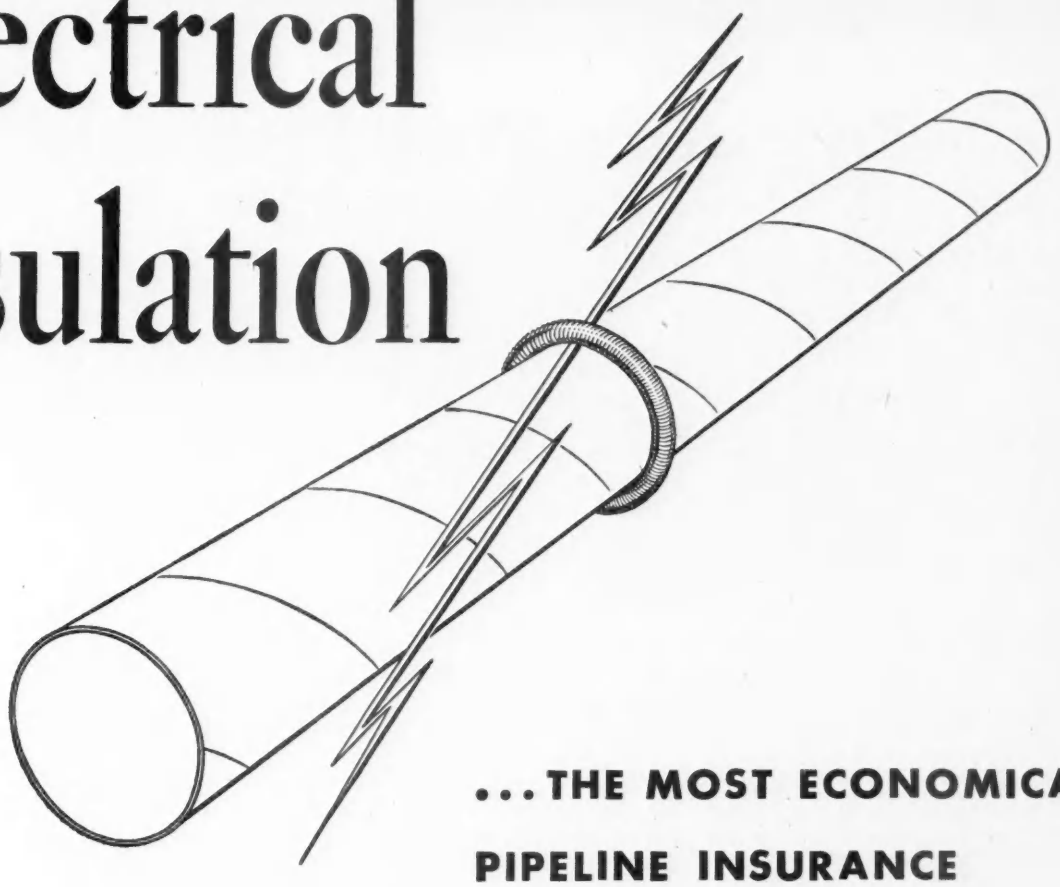
All the above percentages are approximations; they are subject to wide variations under different conditions, different locations, and so on. There are instances where lines show as little as 1/20 of 1 percent bare, attained without excessive coating costs. Probably the ½ of 1 percent quoted is a maximum—almost any new line can be coated that well and still show a profit for the coating.

Old Lines

The case for the old line, already in the ground, with good or bad or no coating, is quite the same in principle, although the answers are very different. The cost of a lot of cathodic protection on one side must be balanced against the cost of taking up and recoating, plus a little cathodic protection, on the other side. This requires a very careful study of costs, and decisions are being made every day on both sides of this question for different lines.

In working through the meshes of these calculations, let us never become so absorbed in the final decision—which is always between alternatives which really lie close together—let us never become so preoccupied with the immediate foreground that we cannot occasionally lift our heads and look around at the whole picture. Some new material, some new technique, may appear at any time, in a field quite distant from where we are working, to give a new and more effective method of keeping iron from running down the energy hill by making batteries out of its environment. Until we can use materials other than iron and steel for our pipe lines, we will always have the same **Why** and **How** of corrosion; but **What** we do about it in the future may be very different from the best we can do now.

Electrical Insulation



...THE MOST ECONOMICAL PIPELINE INSURANCE YOU CAN BUY

Because they possess ability to resist moisture absorption and remain unaffected by the changes in moisture content of soils, Barrett* Coal-tar Enamels provide positive and long-lasting stability of insulation.

These coatings, applied with modern equipment by modern methods, plus electrical inspection, plus cathodic protection, produce corrosion-proof pipelines that require a minimum use of complementary electrical energy and a minimum investment in this form of electrical protection.

The sound economy of coal-tar enamels in conjunction with cathodic protection has been amply demonstrated over a long period of years in all types of soil and climatic conditions.

FIELD SERVICE: The Barrett Pipeline Service Department and staff of Field Service men are equipped to provide both technical and on-the-job assistance in the use of Barrett* Enamel.

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Shot-Peening

To Increase Wear Resistance

MECHANICAL wear of parts of the engines powering pipe line pumps is usually measured in thousandths of an inch, for once the outside surface is destroyed, normal clearances are increased to where knocks, backlash or pound occur, depending upon the type of motion which has caused the wear. Any process or means whereby the life of the outside few thousandths of an inch of a moving part can be extended, therefore, prolongs the useful life of the assembly in which the part is a unit.

Hammering long has been known to increase the ability of certain steels to resist surface wear. A modification of this hammering process, shot-peening, is being adapted to the protection of engine parts against abrasion. The shot-peened surface is not as smooth as that produced by grinding, and so is sometimes damaged by the maintenance man in an attempt to obtain the mirror-like smoothness of a lapped and ground surface.

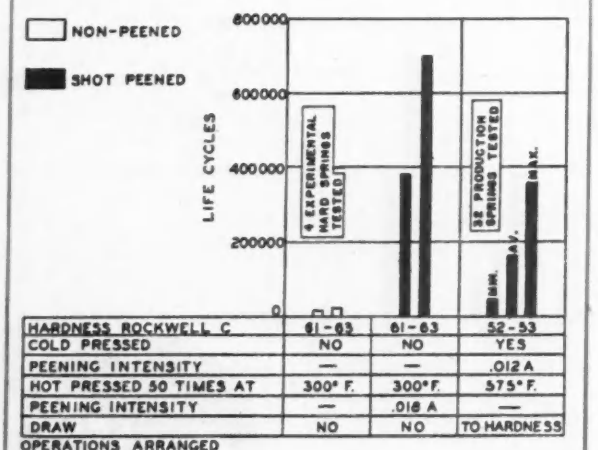
In shot-peening, a spray of metal shot propelled by air pressure or centrifugal force is directed against the surface to be treated. These shot must be round and free from grit, and must be constantly cleaned during use. The impact of each shot against the surface to be hardened has the effect of a blow by a tiny peen hammer, whence the name. The material directly below the impact is compacted, and its grain structure thus refined. Overlapping of the points of impact forms a surface which is considerably denser than the underlying metal. The amount of compaction obtainable by shot-peening varies with the material being treated, the composition of the steel, and its previous fabrication and heat-treatment. The outer layer is in effect cold forged, to a depth which varies from 0.005 to 0.015 inch, depending upon intensity and duration of the peening operation.

Since the layer affected by the peening is so thin, that must be the final process in manufacture of the part. Experiments prove that the surface may be lapped lightly, if a smoother surface than that left by the shot is required. Even the lightest grinding, however, removes most of the beneficial effect gained by the cold working.

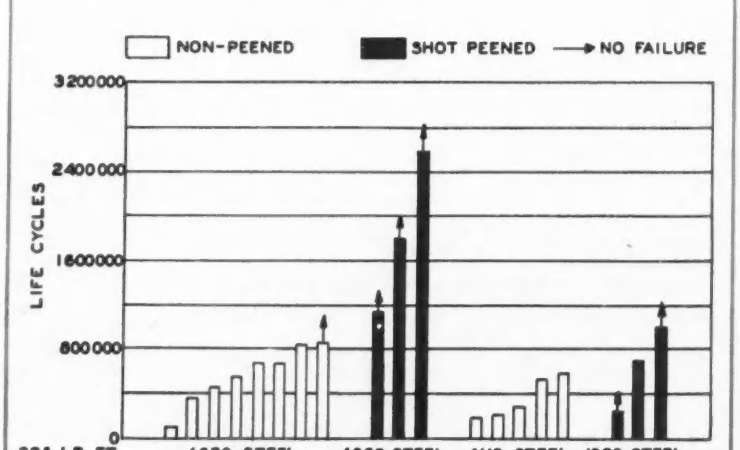
One set of tests made by engine manufacturer on connecting rods proved that the parts which were rough finished and then shot-peened outlasted by several hundred percent units from the same batch which were finished and ground in the usual manner. On a similar test of gears, it was determined that gears of SAE 1020 steel, shot-peened, gave a service life equal to similar gears made from alloy steel which was not given the peening treatment. The life of reduction gears was found in another test to be increased 400 to 600 percent by the use of shot-peening. The slightly roughened surface resulting from the peening also was believed to have contributed to the longer life of such parts, due to the minute oil reservoirs formed by the tiny indentations.

Springs, either of the flat or coil type, usually are benefited by shot-peening. In a series of tests on coil springs, the shot-peened units lasted considerably longer than the conventional ones. The compressive strength set up in the surface by the peening was believed to relieve brittleness and reduce sensitivity of notch effect. This is especially desirable where the springs must be operated under high-stress concentrations. Since nearly all spring failures start from surface defects and/or stress concentrations brought about at these points, the effect of peening is to prolong the surface life of the unit, and thus enable it to pass through many more operating cycles than would be the case were the surface free to set up concentration nodes at minute scratches, nicks or tool marks. It is this stress concentration at any sharp irregularity in the surface which requires that the shot be thoroughly and continuously cleaned during the peening operation, as otherwise sharp corners on fractured shot would cause the very scratches which the treatment is supposed to prevent.

Two graphs, taken from an article on shot-peening by Fred K. Landecker and presented before a West Coast meeting of the Society of Automotive Engineers, illustrate the surprisingly large increase in service life of shot-peened over conventionally treated parts.


NON-PEENED
SHOT PEENED
LIFE CYCLES
800000
600000
400000
200000
0
4 EXPERIMENTAL HARD SPRINGS TESTED
38 PRODUCTION SPRINGS TESTED
MIN.
AV.
MAX.
HARDNESS ROCKWELL C | 61-63 | 61-63 | 52-53
COLD PRESSED | NO | NO | YES
PEENING INTENSITY | — | — | .012 A
HOT PRESSED 50 TIMES AT | 300° F. | 300° F. | 575° F.
PEENING INTENSITY | — | .018 A | —
DRAW | NO | NO | TO HARDNESS
OPERATIONS ARRANGED IN SEQUENCE

Effect of shot-peening on the fatigue durability of brittle springs as compared with that of the softer production springs.



Effect of shot-peening on fatigue life of carburized transmission gears.

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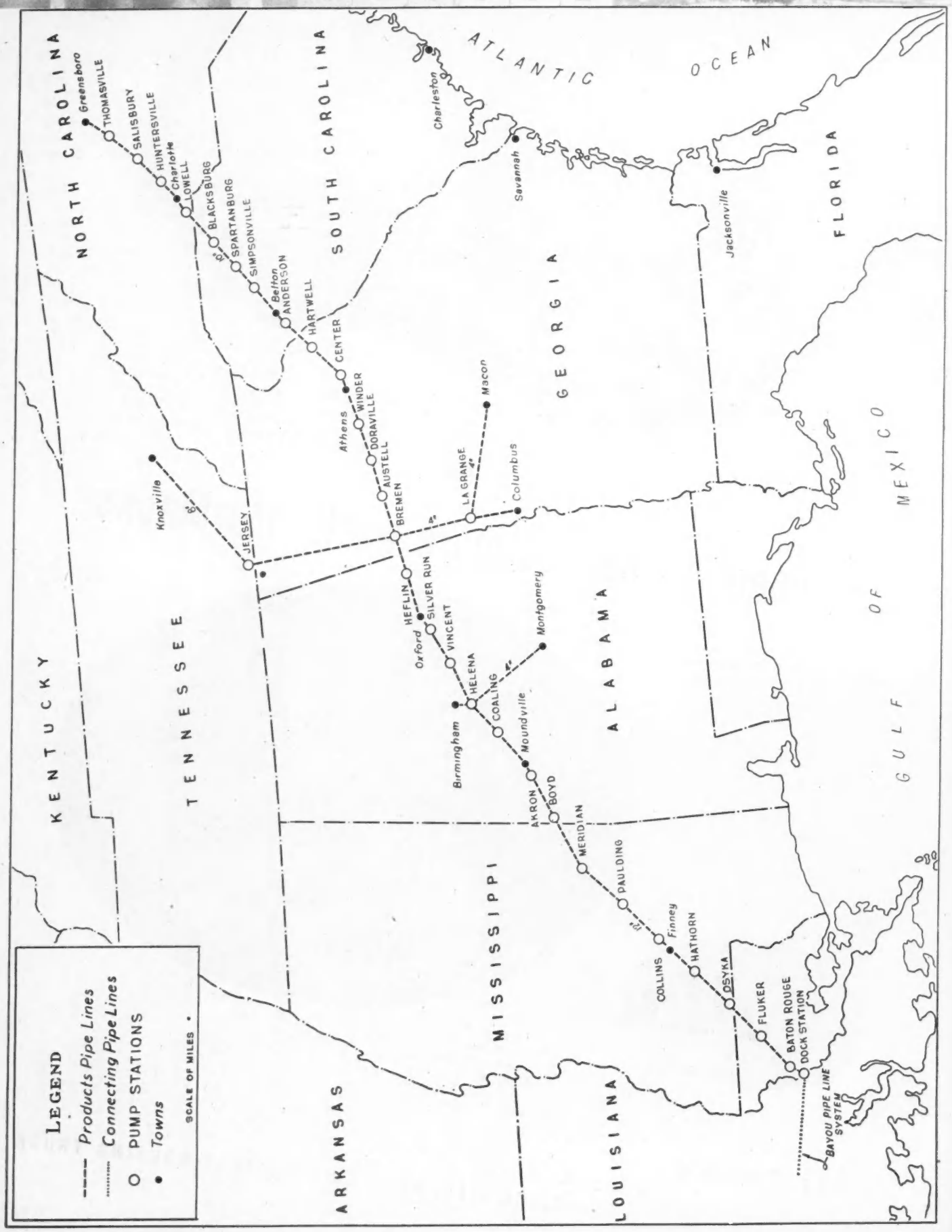
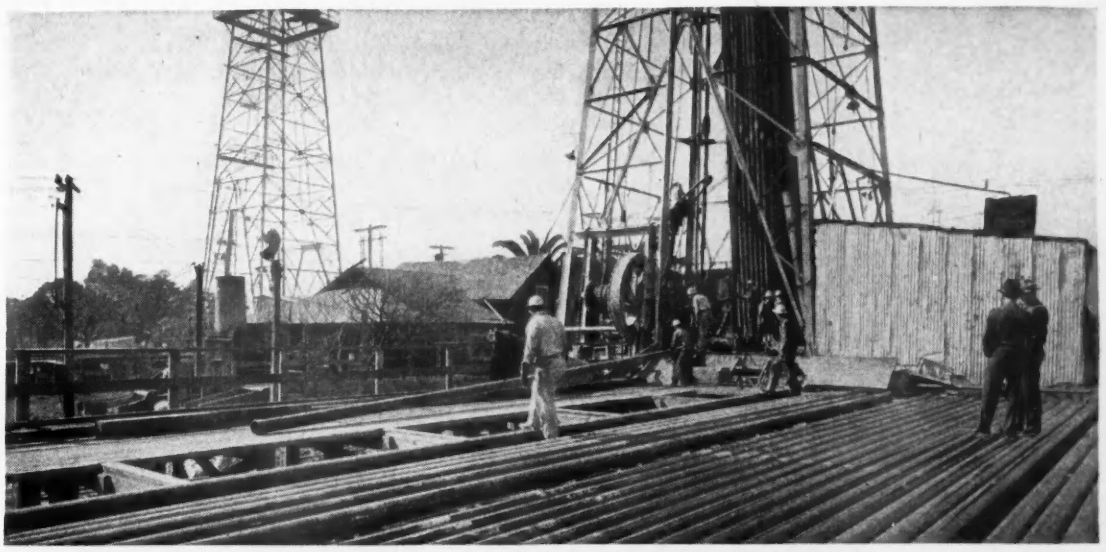
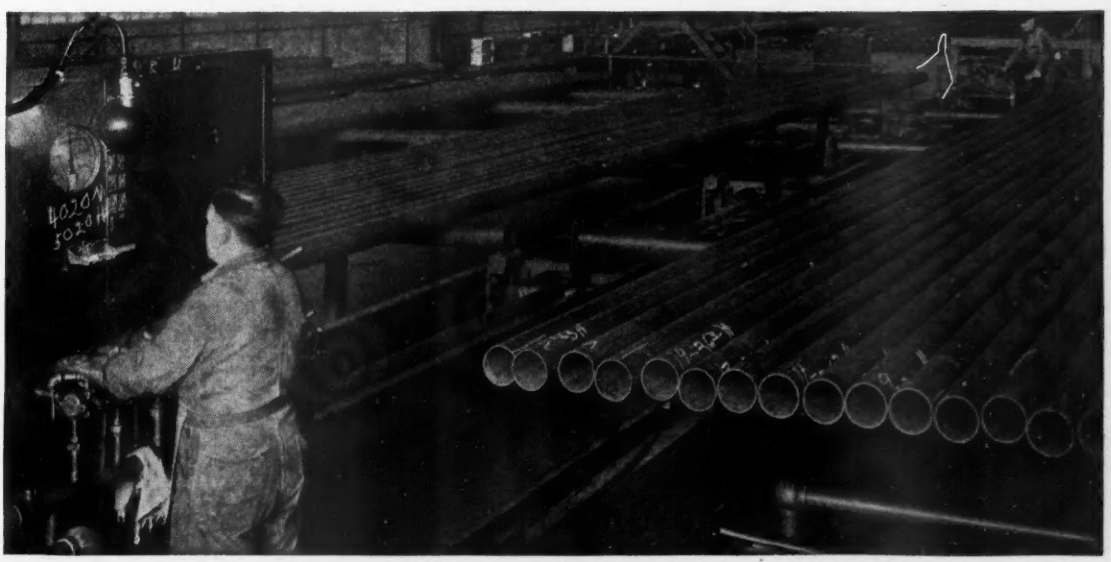


DEPENDABILITY



IN A CALIFORNIA FIELD: Running seven-inch S-80 SMITHway Casing.

THROUGH RESEARCH



IN THE A. O. SMITH MILL: Hydrostatic-testing S-80 SMITHway Casing.

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COMPOSITE CATALOG

Published by WORLD OIL

THE GULF PUBLISHING COMPANY HOUSTON 1, TEXAS U.S.A.

PIPE LINE *Construction*

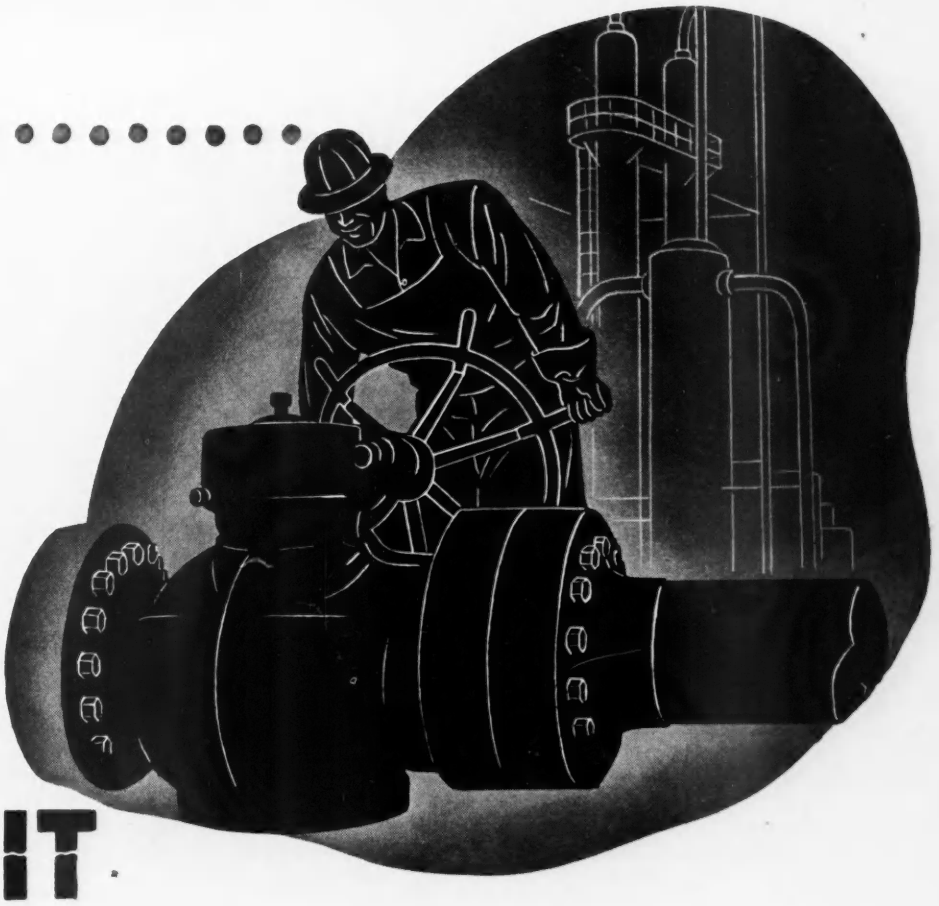
AS RISING March temperatures somewhat lightened the demand for gas and fuel in industrial northern and eastern centers, encouraging news was heard from many companies who are planning large expansion or development of inadequate pipe line facilities. Business men of Detroit, which earlier had almost 100 plants closed for lack of natural gas, took their troubles to Washington, and were told that relief in New York, Pennsylvania and West Virgonia households must come first. Most plants are now reopened and several FPC decisions are designed to relieve the previously mentioned areas.

An important development was the approval of the merger of Memphis Natural Gas Company and Kentucky Natural Gas Company into Texas Gas Transmission Corporation. The new corporation is planning a $60 million gas pipe line from East Texas to Ohio, running directly to Memphis, Louisville, and areas where gas shortages this winter have been severely felt.

Pipe Line Construction Activity

COMPANY	Origin and Terminus	Length (Miles)	Pipe Size (Diameter)	Daily Capacity (Bbls. Cu. Ft.)	Remarks
CRUDE OIL LINES					
Continental Oil Co., Pipe Line Div.	Point 25 miles north Cheyenne, Wy., to Denver, Col.	100	10	.....	100-mile spread to be built by Osage Construction Co.;
		18	10		18- and 30-mile spreads contracted by Goldenstern
	Point 19 miles north of Chugwater, Wyo., running south	30	8		& Stolpen Construction Co. Work to start April 1.
Frontier Refining Company	Mush Creek and Ant Hills fields, Weston Co., Wyo., to Rocky Mt. Pipe Line Co. line at Lance Creek field near Lusk	65	....	4500-6000	Application filed with Colorado Public Service Commission; Rocky Mountain's line supplies Cheyenne and Denver refineries.
Gulf Refining Company	Alameda to Raywood station loop, Upper Texas Coast	15	8	.....	Construction completed by Latex Construction Co., Houston.
Humble Pipe Line Company	Albany to Woodson Station, West Central Texas	11½	6	.....	6-inch line replaces 5 miles of 4-inch. Completed by Royce L. Boyd, Cisco, Texas.
	Hastings field, Galveston Co., to Webster station, Harris Co., Upper Texas Coast	6⅞₁₀	8	.....	Contract to replace two 4-inch lines of 6⅞₁₀ miles awarded to Latex Construction Co. Scheduled completion end of March.
	Point 4 miles south Pettus station, Bee Co., to point 13 miles south of station, near Refugio, Southwest Texas	9	8	.....	Replacement for 6-inch line to be completed by Massey Pipe Line Construction Co., Corpus Christi, Texas, end of March.
	Atascosa, near Campbellton	6⅞₁₀	12		Looping between Lytle station, Medina Co., and Ingleside station, San Patricio Co., being handled by Sheppard-Geiger Construction Co., Corpus Christi; scheduled completion end of April.
	Near Beeville	7½	12		
	Near Sinton, San Patricio Co., Southwest Texas	9⅛	12	.....	
Imperial Pipe Line Co.	Junction with present pipe line at Nisku to Edmonton, Alberta, Canada.	17	8	.....	Work planned for summer 1948. No contract awarded
Imperial Oil, Ltd.	Leduc field to Moose Jaw and Regina, refineries, Sask. Canada.	500	.....	.....	Plans under consideration refer to 10 or 14-inch line possible 350-mile extension to Winnepeg.
Mercury Refining Co.	East Brady field to Interstate Oil Pipe Line Co.'s 10-inch line, Okla.	5	4	1000	Construction being planned.
Pan American Pipe Line Co.	Gladewater to Big Sandy, East Texas	10	4	.....	Salvage job completed by Titsworth & Partain, Kilgore, Texas.
Phillips Petroleum Co.	Old Ocean field to plant at Sweeny, Upper Texas Coast	18	8	.....	Associated Contractors & Engineers, Houston, started work in mid-March.
		2	6		
		2	4		
Shell Pipe Line Corporation	Wheeler to Wink, West Texas	20	10	.....	Construction of lines to feed Jal-Cushing system planned for later 1948.
	Wasson, West Texas, to Hobbs, N. M.	33	12		
	Hobbs to Jal, N, M.	40	14		
Skelly Oil Company	Velma field, Stephens Co., Okla.	9	6	8000	Gathering system completed by Bishop and Lock Construction Co., Dallas.
Socony-Vacuum Oil Company, White Eagle Div.	Morel field, Graham Co., to Adell field, Sheridan Co., Kansas	42	6	.....	Contract awarded to Knupp Construction Co., Great Bend, Kans.; scheduled completion date end of April. Delay anticipated.
Standish Pipe Line Co.	Pampa, Texas area	25	6 & 4	.....	Take up and recondition job being done by Klein & Barnette Construction Co., Borger, Texas.
The Texas Pipe Line Co.	East Houston station to Port Arthur and Port Neches refineries, Upper Texas Coast	87	20	.....	Contract awarded to Latex Construction Co.; work scheduled to begin late March.
	West Columbia to Houston, Upper Texas Coast	60	16	.....	Contract to be awarded in May.
	Corsicana junction to Wichita Falls booster station on Jal-Cushing line, East Texas.	196	12	.....	Project planned by company.
The Texas Pipe Line Co., Shell Pipe Line Corp., Empire Pipe Line Co., Sinclair Pipe Line Co. (Basin Pipe Line System).	Wichita Falls, Texas, to Cushing, Okla.	175	24	.....	Contract on last section of Jal-Cushing line to be awarded in June.
PRODUCTS LINES					
Chinese National Resources Committee.	Yumen field to Kinchuan, Kansu Province, China	60	.....	1500	Government hopes to build in 1948.
The Texas Pipe Line Co. and Magnolia Pipe Line Co.	Hearne to Dallas, North Texas	146	10	.....	146-mile spread completed late March; work beginning
	Dallas to Ft. Worth	26	8	.....	on 26-mile section: Associated Contractors & Engineers, Houston.
Triangle Pipe Line Co.	Carthage to Larosen, near Shreveport, La.	40	8	20,000	Completed by Rosson-Richards Co., Corpus Christi.
NATURAL GAS LINES					
Dow Chemical Co.	Near Freeport, Upper Texas Coast	14	8	.....	Takeup and recondition by Latex Construction Co.
		23	8		scheduled to start end of March.
		25	4		

(TABLE CONTINUED ON PAGE 202)



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Pipe Line Construction Activity (Continued)

COMPANY	Origin and Terminus	Length (Miles)	Pipe Size (Diameter)	Daily Capacity (Bbls., Cu. Ft.)	Remarks
El Paso Natural Gas Co.	Loops paralleling portions of existing line for Lea County, N.M., to Blythe, Calif.	601	26	200 mln.	Amended application sent to FPC. Construction to begin as soon as permission granted for completion by November 1950, or not later than January 1, 1951.
	San Juan County, N.M. to Needles, Calif.	470	26	100 mln.	
	Cross-over line, point 45 miles east of Blythe	96	24	200 mln.	
Empire Southern Gas Co.	Shafter Lake field, Andrews Co., to El Paso's Fullerton station, West. Texas.	10	8	10 mln.	Construction scheduled to complete end of March by El Paso Natural Gas crews.
Kansas-Nebraska Natural Gas Co.	Otis, Rush Co., to Plainsville, Rook Co., Kansas	50	8	.....	Construction to start when weather permits.
Lone Star Gas Co.	Opelika to Greenville, Texas	66	18	.....	Construction by company crews planned when weather permits.
Northwest Natural Gas Co.	Canadian border, near Kingsgate, B. C. to Seattle	606	24	209 mln.	Application to FPC. Construction planned for 1950 or earlier, if materials available. Line originates in Alberta gas fields.
	Seattle to border, near Vancouver	150	18		
Skelly Oil Company	Velma field, Stephens Co., Oklahoma	25	4–20	30 mln.	Construction by Bishop and Lock Construction Co. Dallas, to start April, complete July, 1948.
Southern Natural Gas Co.	Gwinville to Brookhaven, Miss.	40	8	.....	Latex Construction Co. starting project April.
Stanolind Oil & Gas Co.	Slaughter field, West Texas	320	2–30	.....	Deaton & Sons, Odessa, Texas, to start laying pipe April.
	Wink, West Texas	35	.....	.....	McVean & Roberts, Odessa, Texas, laying gathering and distribution system.
Tennessee Gas Transmission Co.	Main line loops between station 5 and 11, from Natchitoches, La., to Portland, Tenn.	150	30	60 mln.	FPC granted permission; construction to begin immediately.
	Main line valve station No. 76 to valve station No. 82, Tenn.	67 9/10	26	.....	Loop to be constructed by Morrison Brothers, Odessa, starting April 15.
Texas Eastern Transmission Corp.	Hico-Knowles field to Little Big Inch connection, La.	3 7/10	14	.....	Application to FPC to remove 14-inch pipe from Enfield, Ill., area and substitute for 4 miles of 12¾-inch line. Philadelphia lines to be obtained from Linden, N. J. area and elsewhere near Philadelphia.
	Philadelphia area	8	12	.....	
		1	6	.....	
		1 1/3	12		
Texas Gas Transmission Corp.	East Texas to point near Middleton, Ohio	800	26	.....	Planned by company, application to be made to FPC.
The Texas Production Co.	Lake Salvador and Delta Farm fields to LaFitte plant, La.	17	8	.....	Associated Contractors & Engineers, Houston, to complete end of March.
United Gas Pipe Line Co.	Soso field to main line connection near Laurel, Miss.	20	12	.....	Associated Contractors & Engineers to start pipe laying late March or early April.
Western Prairie Pipe Line Co.	Calgary, Alberta, to Winnipeg, Manitoba, Canada, with laterals to Saskatoon, Prince Albert, etc.	850	.....	.....	Application is being made to Canadian Parliament for permission to incorporate.

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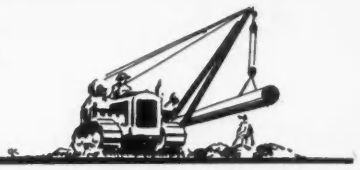
PIPE LINE HINTS



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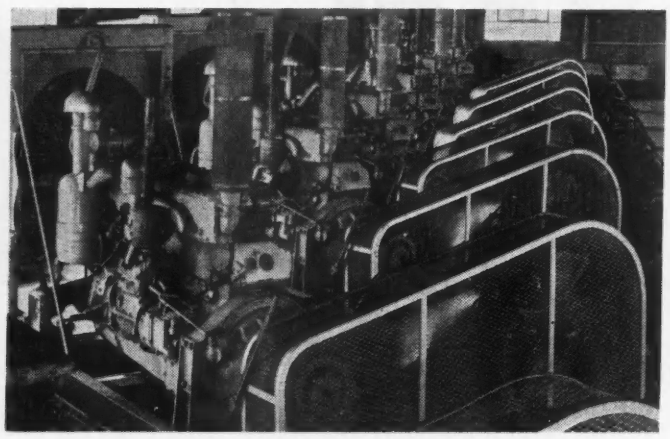
How To—Utilize Maximum Space in Pumping and Booster Stations



Considerable space can be saved in pipe line pumping stations by systematic arrangement of engines and pumps. A battery of crude oil pumps is illustrated. Each 5 x 10-inch pump is belt-driven by heavy-duty diesel engines. When these two units are mounted so that their individual skids are joined together, the complete assembly is shaped in a large "L", with the engine forming the short leg of the ell.

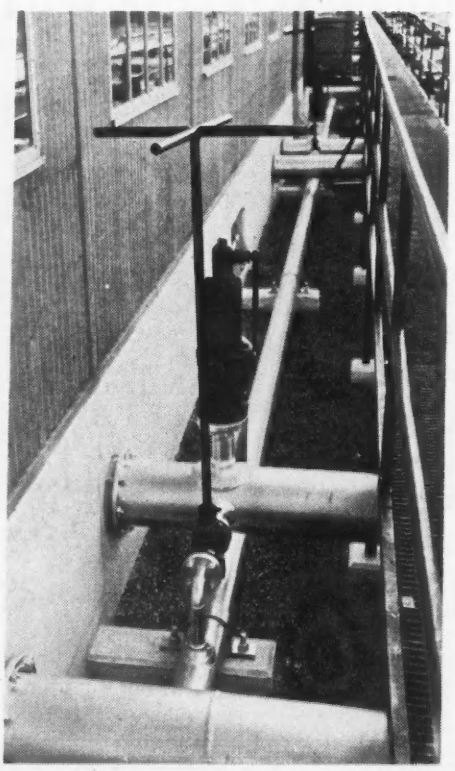
Instead of placing these units so the pump and engines were parallel to the sides of the station building, each unit was anchored at an angle with the building as shown. In this manner, the "L" shaped units could be nested more closely to the adjacent unit, placing all the engines parallel to each other and the pumps parallel to one another. There still remained adequate space between the individual units for inspection and repair work, and the belt drive was completely covered with an expanded metal guard to prevent accidental injury to station engineer and crew. Intake and discharge lines are set below the concrete floor, making a very neat and efficient pumping station.

How To—Add Convenience to Valve Operation on Discharge Bleed-off Line

The high-pressure discharge lines on a battery of pipe line compressors emerge through a concrete sill poured on one side of the compressor building. When it is necessary to repair any one of the compressors, the discharge line must be cut off from the main transmission line and the pressure contained in this discharge line back up to the discharge valves on the compressor must be exhausted before work can procede safely.

Bleeding the discharge line of high pressure gas was accomplished in a systematic manner that carried the exhausted gas through a four-inch vent line. The vent manifold crossed all the high-pressure discharge lines so that every compressor could be safely bled down when it became necessary to make repairs. The exhausted gas was then carried to a point a safe distance from the building where the gas was vented.

The high-pressure tie-in between the discharge line and the vent manifold was made adjacent to the metal walkway which traversed the top of all piping coming from the compressor station.



Reinforced welded connections were made to the discharge line and vent line through a heavy-duty, flanged, plug valve. Location of the plug valve made it difficult for workmen to open the valve and vent the gas. An extension and cross-bar handle solved the problem as well as afforded a means of indicating the position of the plug in the valve.

A socket was made to fit the square shoulder on the plug stem and then welded to a section of one-inch pipe about four feet long. The valve stem socket was equipped with a set screw which prevents the socket from accidentally being dislodged. To the top of this valve stem extension was added cross pieces welded at 90-degree angles to one another to form a convenient handle with sufficient leverage to manipulate the plug valve. Each handle was approximately one foot long from the center of the extension pipe. The tip of one handle was painted yellow to indicate the position of the plug opening. In the position shown, the valve is closed, which is readily determined at a glance.

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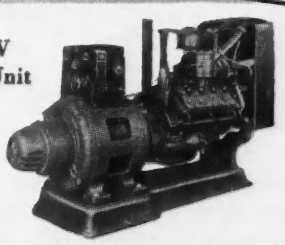
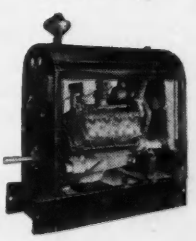
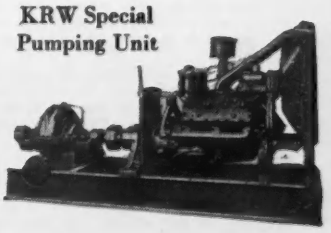
KRW 20KV Generating Unit





KRW Industrial Power Unit (enclosed type)

KRW Special Pumping Unit



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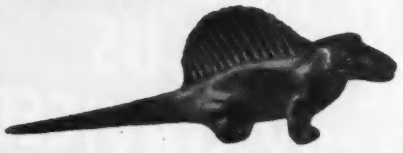
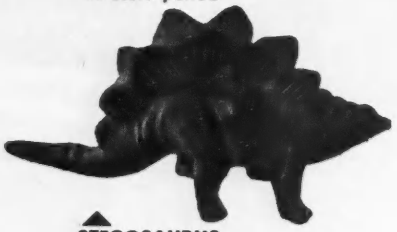


DIMETRODON
Permian period

TYRANNOSAURUS
Triassic period



STEGOSAURUS
Jurassic period

TRICERATOPS
Late Cretaceous period

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Upper Jurassic period

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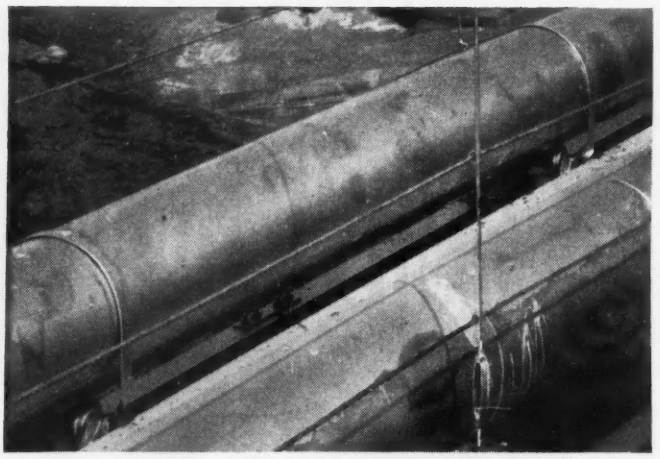
How To—Compensate for Line Changes on Bridges



Pipe lines exposed to the weather on suspension bridges will expand and contract according to temperature variations to cause some movement between the pipe and the pipe saddle. In arid climates where the temperature changes between heat of day and chill of night are great resulting in considerable movement in the pipe, it is possible after years of service for the pipe to rub a weak point in the wall at the contact face.

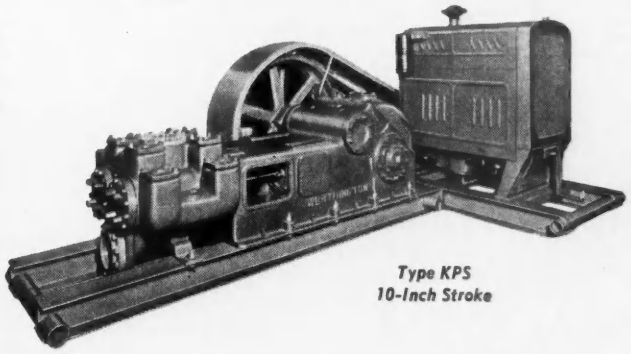
This problem was solved by employing rollers designed to fit the contour of the pipe and which provided the necessary support for the pipe. The rollers were set in bearings and were mounted to cross braces of the suspension bridge. Points of contact were provided about every eight to ten feet. The pipe was clamped to the bridge and to the roller cradle, but changes in length due to temperature changes were permitted. The pipe expanded and contracted over the rollers, eliminating undue friction between the pipe and its support.

How To—Guard Against Electrical Accidents

Pipe line pumping stations, terminals, and booster stations handling highly inflammable petroleum products must take every precaution against the ever-present danger of setting off a spark in the gas-filled buildings and pump houses. These plants, which during this time of peak demand for petroleum products, must operate 24 hours around the clock, and are lighted with hundreds of electrical light bulbs incased in vapor-proof housings. It is quite natural that some of these lights would burn out occasionally and need replacement. It is also expected that additional circuits be added to those already existing, in which case the circuit must remain open until the addition has been completed.

In these highly combustible areas, the slightest spark will set off a disastrous explosion, and to guard against this possibility, the electrical department of one company employs caution signs to inform employees that a circuit has been shut off for repairs. These caution signs are hung over the control panel of the circuit in question. The signs are standard equipment with the electrical department, and electricians are instructed to place them on all lighting panels before replacing burned out bulbs or making any repairs to the circuit. When the job has been completed, the sign is removed and the circuit again placed in operation.

LOCKETT-WORTHINGTON POWER-DRIVEN PUMP UNIT



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PIPE LINE HINTS

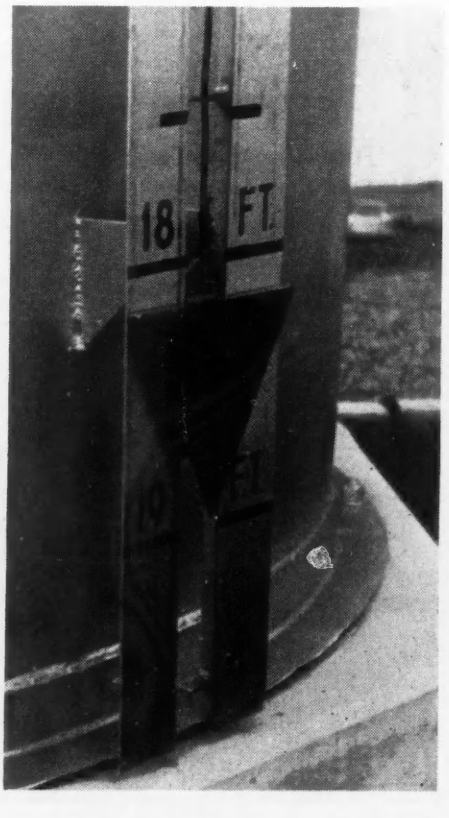
top to provide a minimum of obstruction to a man crawling through it. Such a feature makes it convenient to lock the window from the inside.

A permanent set of steps were included during the concrete casting and were made from solid steel rod material. They were shaped in a "U" form and project far enough from the wall to provide easy stepping. Such construction insures a means of getting out at all times, and it is impossible to move the steps as would be the case where a portable ladder might be used. In case of fire in the building where the stairway is blocked, this escape hatch provides an ever-available means of getting out of the cellar. It is useful too, in venting the gases from the building.

How To—

Make Fluid Level Marker

Where it was necessary to keep a constant check on the amount of water in the engine cooling water surge tank at one compressor station, the old positive liquid level indicator was employed. The principle was the same, whereby a floating element on the water surface was connected to an external indicating device that was carried up and down in a calibrated track, but improvements over the old indicator made it a superior instrument.



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Your engine's heart zone is its heat zone—the top cylinder area. That's where vital valves must work—where heat is hottest, especially in gas-fueled engines—where sizzling temperatures scorch lubricants and leave bare metal unprotected . . . that's where Marvel Mystery Oil and the Marvel Inverse Oiler really go to work!

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This cooler is corrugated for greater strength and durability being of all welded construction. It is fully insulated with granulated cork to keep water colder longer. Added features include, conversion from spigot to non-spigot type, no solder joints to break out and a reinforced innerbottom.

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The floating element was attached to the indicator by means of a flexible galvanized cable that rode on a covered pulley mounted at the tank's top edge. Weight of the float had to be greater than that of the indicator plus the cable to insure positive following of fluid level. It was also necessary that the pointer or indicating device be of sufficient weight to keep the cable tight, thereby giving an accurate reading.

The gauge face consisted of two pieces of strap steel welded to tank wall brackets as shown, to keep the two straps several inches from the tank. These straps formed a track which guided the indicator up and down the side of the tank. The indicator was made from ¼-inch steel sheeting and was split along its horizontal edge to accommodate the track provided by the gauge face. Instead of making a rectangular face, which might confuse some operators in reading either the top edge or the bottom edge, depending upon their individual interpretation, the face was shaped in a triangle. One point of the triangle was directed downward, so the horizontal edge was on top, and it was this top edge that was used in making all liquid level determinations. This edge completely covered the gauge face, and the pointer or indicator was painted a contrasting color for ease in reading.

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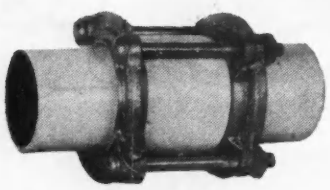
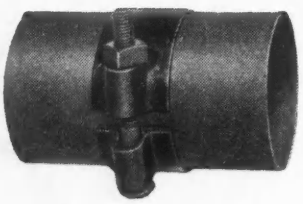
. . . Without shutting down the line. Just put a Dresser Repair Clamp around the leaking pipe—draw up the bolts—and in a matter of minutes, you've made a bottle-tight repair.

The four styles shown here are just part of Dresser's complete line of repair products. See them at your oilfield supply store or write for our Oilfield Catalog. Overnight delivery throughout the southwest from our Houston warehouse. Keep Dressers in stock and have the jump on emergencies.



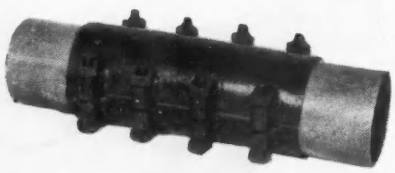
COLLAR CLAMP

Styles 4 and 41, for repairing and preventing leaks through threads of screw collars.



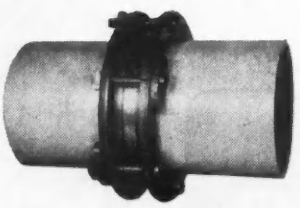
BAND CLAMP

Style 77B, for repairing small leaks and holes in the run of pipe.



SPLIT REPAIR CLAMP

Style 79B, for repairing pitholes and longitudinal splits in pipe.



POROUS-WELD CLAMP

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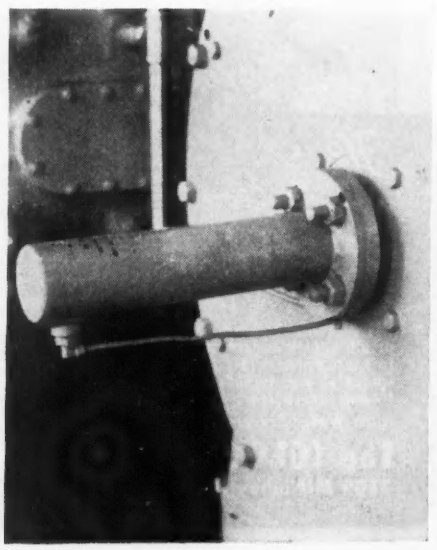
How To—

Protect Engine Tail Shaft

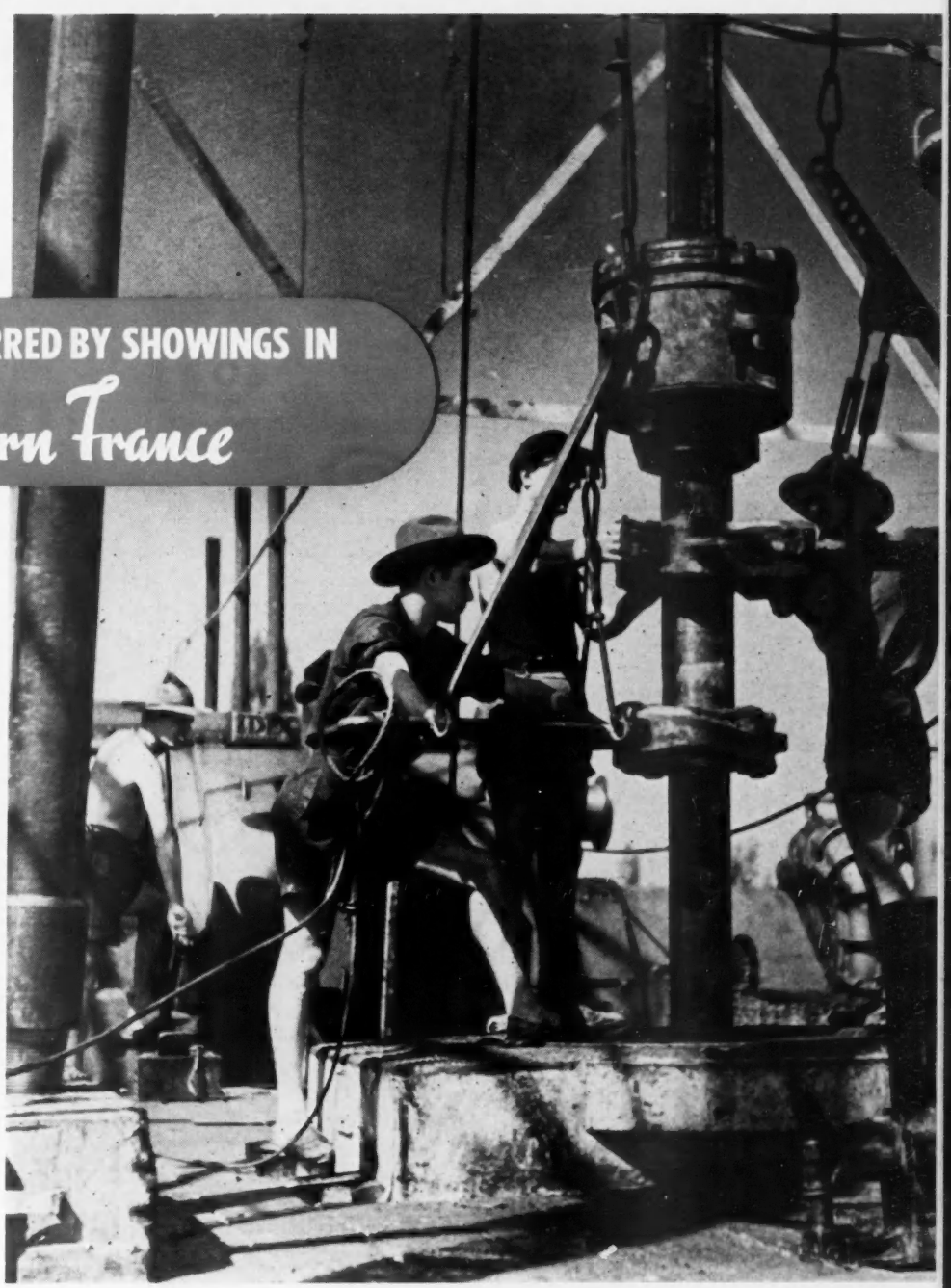
The housing over the tail shaft on the combustion air cylinder of a compressor engine was covered with a tubular shield which had a half-inch hole in the end to allow for air passage as the shaft reciprocated in the narrow space. This relatively small aperture, directed across the aisle of the station, caused a draft which was objectionable, and at the same time the air thus expelled carried out droplets of oil which kept the floor discolored where they fell.

By welding a plug in the vent at the end of the cover, and drilling a pattern of quarter-inch holes on the upper quarter of the tube near the end, vents were provided for the displacement air in the cover, and the flow was directed upward where it did not reach the aisle.

The small holes broke up the stream of outgoing air, and thus greatly reduced its capacity for carrying droplets of oil. As a result, most of the entrained oil remained within the tube, being caught in the small sump at the outboard end of the cover and returned to the crankcase through a drain tube installed for that purpose.



EXPLORATION SPURRED BY SHOWINGS IN Southern France



EXPLORATORY work in Southwestern France was hampered during the war years and immediately thereafter, but nevertheless resulted in delineation of many prospects. With increased availability of equipment and materials, an active program is getting under way to test geological and geophysical structures by actual drilling.

By E. N. TIRATSOO,
Staff Correspondent

Drilling well on St. Medard structure where gas showings have been found in Triassic formations.

EXPLORATION activities of the French company, Societe Nationale des Petroles d'Aquitaine (SNPA) has resulted in the recent discovery of oil at Audignon in Southwestern France, the second oil-producing area in that section. The only other production in Southern France is on the adjoining concession of the Regie Autonome des Petroles where one well produces approximately 20 barrels daily.

The first oil well on the SNPA properties came after seven years of prospecting in the 10,000-square-mile area, although only within the past couple of years have the operators been in complete possession of the properties, with enough equipment and supplies to carry on an active drilling program. When the company was formed in December, 1941, the Germans were occupying a portion of the area and communication was difficult within the boundaries of the concession itself as well as with other regions. Since the close of the war more equipment has been secured, and now there are five rigs on the concession capable of exploring the Jurassic, Triassic and Cretaceous formations thought to be most favorable as sources of future production. However, only two of these rigs are new. Evidence of accelerated drilling activity is shown in the 40,420 feet of hole drilled in 1947 alone, whereas all drilling prior to the beginning of that year amounted to slightly less than 46,000 feet.

The Audignon discovery is in the Department of Landes, 35 miles north of the city of Pau and five miles southwest of Saint Sever. Although a small producer on the basis of present testing, it is offering definite encouragement for continuation of work in the Pyrenees foothills trend. The structure is anticlinal in nature with a thrust fault on the southeast side, originally picked up by surface geology, being one of the few structures in the area apparent on the surface, but was later checked out with some subsurface work and closure

checked with seismograph and gravitymeter. The oil is found on the southeast block against the fault. It is producing from dense oolitic limestone at 7049 feet, with total depth 7120 feet. Formation is not yet identified but is thought to be Jurassic, although some indications of Triassic were noted while drilling above this depth. The well will go on the pump, and the only tests made to date have been by swabbing, recovering about 12 to 15 barrels daily of heavy, asphaltic oil, about 22 gravity.

SNPA History

The SNPA was formed in December, 1941, as a result of a government decree which assigned it the duty of exploring for petroleum in a concession area in the southwest portion of France. The concession outlines are indicated on the map, it having been delineated by lines running through certain towns in the area to enclose the property. In October, 1942, the government granted to the company the exclusive rights of exploration and development of oil and gas resources within the area. The original capital of 230 million francs was subscribed 55 percent by the government and 45 percent by 12 private companies, among which the largest single participant is Compagnie Francaise des Petroles. The 1946-47 capital was increased to 620 million francs and is now being increased to 930 million. Increases in the capitalization have come from the original stockholders plus a few others which have joined the enterprise.

The original technical staff members were composed largely of French engineers who had been working for the French companies in Roumania and who left as a result of that country's pro-Axis policies in 1940 after having remained long enough to help destroy part of the installations to keep them from German hands. In 1941 most of these men were back in France and working under the leadership of Pierre Angot, former head of Steaua Romana Company who had been placed in charge of SNPA, and who later became president of RAP as coordinator of France's oil search. During the German occupation Angot, as well as the management of RAP, made himself unpopular with the occupying forces by hampering German efforts to develop the area after the gas discovery at Saint Marcet. As a result he was arrested when the Allies landed in Normandy in June, 1944, and later sent to Germany, where he died after having labored in the Plomnitz salt mines. M. Blanchard followed Angot as president and director-general of SNPA.

In the beginning the company was plagued by personnel and equipment shortages. The number of experienced oil men available was too small for a concentrated program, and despite attempts at training, a personnel problem continued through most of the early years of prospecting. Equipment of all kinds was lacking and it was impossible to purchase any from the U. S. Two drilling rigs were borrowed from RAP, which in turn had secured them from the Societe Cherifienne des Petroles. However, these were both 1935 models and by no means adequate for the type of drilling they were called upon to do. They were put to work in the eastern part of the concession, the first being on the Lavelanet structure and the second on the Treziers dome. The choice of the eastern part of the concession for the initial drilling was prompted more by political than geological considerations. The area which seemed most promising was actually in the western part of the concession, but since this zone was near the coast the presence of the Germans there made development almost impossible.

In the years preceding the liberation, an intensive geological program was initiated in order to prepare for the increased drilling activity which would be made possible with the close of the war. Just before the war RAP had discovered the Saint Marcet gas field in the area north of Saint Gaudens. As a result of this discovery the concession granted to the RAP included a number of surface structures known as the Little Pyrenees, which form a folded foreland zone to the north of the main Pyrenees Mountains.

In the case of the SNPA concession there were comparatively few structures evident on the surface, such as Audignon, Bastennes-Gaujacq and Sainte Suzanne in the west, and Dreuilhe in the east, while for the most part the entire area is covered by Tertiary deposits under which the structures must be found by geophysical means or subsurface geology after drilling has proceeded to some extent. For this reason a program of electrical resistivity surveys was started in 1941 and continued through 1943, resulting in the delineation of the principal structures now known on the concession.

Basin Found

A large basin was discovered in the foothills of the Pyrenees bounded on the north by a plateau which rose at a gentle angle of dip toward the Central Massif. This basin is now generally called the Upper Cretaceous Basin since it coincides with deposits of that age. Several anamolies were found on the edge of this plateau which were confirmed by other geophysical methods during subsequent years. In 1945 a resistivity survey was made over the northern part of the concession which had not previously been prospected, and a gravity survey has started which should be completed some time this year. This will complete the survey of the concession by these methods.

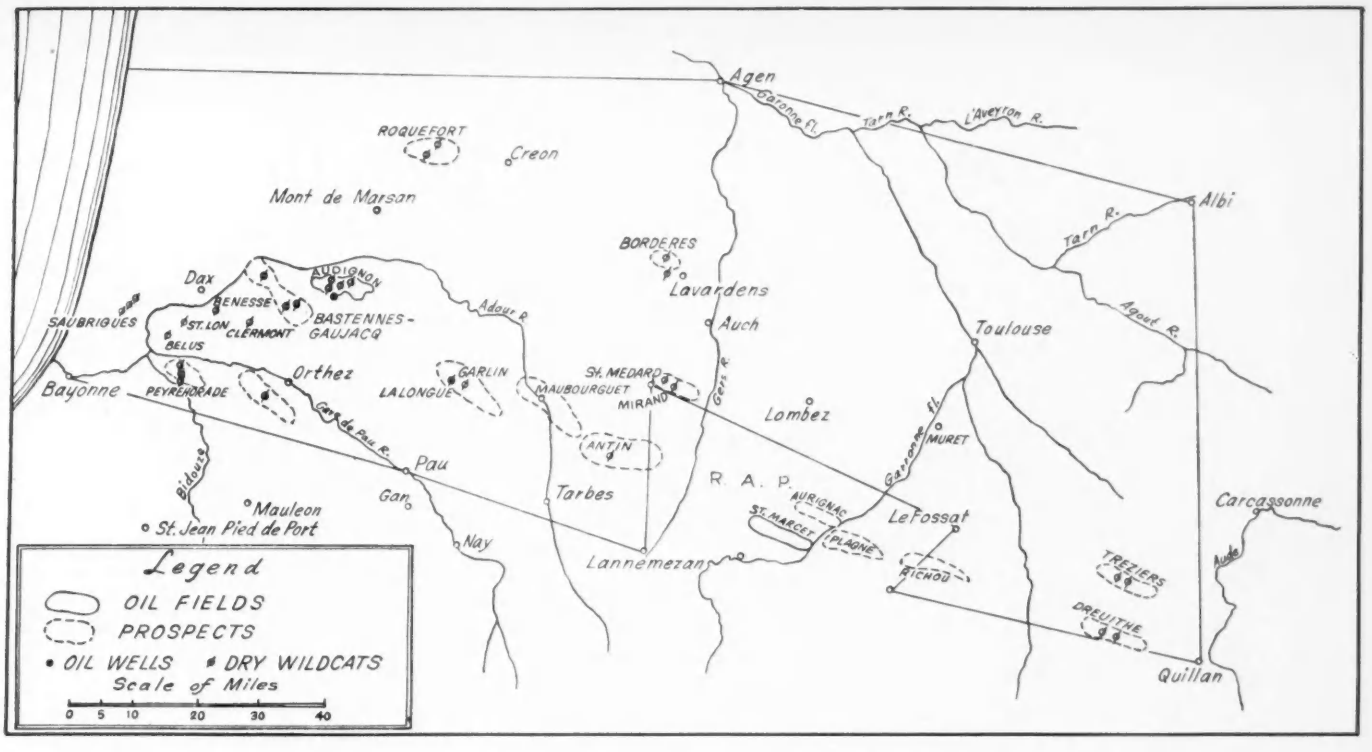
Seismograph geophysical work has been carried out in the Saubrigues area on the western edge of the Basin, and also at points on the northeastern and southwestern edges of the basin where the previous surveys had indicated anamolies. These surveys, coupled with results of wildcat drilling, have caused a reorientation of the exploration program. It had been supposed originally that the potential reservoirs would be found in the Upper Cretaceous beds as was the case in the RAP concession, but wherever these formations have been penetrated in the SNPA concession they have been found barren. It is now concluded that they are only likely to be productive when overlain by a cover of Flysch rocks. This Flysch series is absent except in the extreme southern part of the concession where the surface structures are generally complex and deeply eroded, so the structures in this area will have to be found with seismograph work. Surveys are now being started in the Pau area with this in view.

Elsewhere in the central part of the concession, structures such as Garlin, Maubourguet, Antin and St. Medard were discovered by geophysics, but since hope of finding Upper Cretaceous production in this part of the basin is slight, the structures themselves complicate the problem of exploring the older beds. The anticlines are believed to be the result of Diapiric plugs which seem to have passed through a considerable thickness of sediments, and the strata believed to be potential reservoir beds are upturned on their flanks. Exploration will have to be on the flanks, and outlining of structures at reservoir depth will have to be largely the result of drilling.

Here, as in the northern part of the concession, hopes for oil production now seem to be largely from the lower section of the Middle Cretaceous (Lower Cretaceous is absent), from Jurassic, and perhaps in the Triassic or deeper. These hopes have been furthered by the finding of oil on the flank of the Audignon structure. Important gas showings also have been noted on wells on the Garlin and Saint Medard structures after drilling a considerable way into the Triassic, although it is not known whether the gas comes from the Triassic itself or from some other formation.

If oil is to be found below the Cretaceous, the northern part of the concession should be the most favorable, since the Cretaceous thins out toward the north and is completely absent in the Agen region at the northern boundary.

In brief, investigation to date has indicated the most likely portions of the



Societe Nationale des Petroles d'Aquitaine concession, showing structures to be explored.

concession in the several likely oil-bearing formations as follows:

1. Lower part of Upper Cretaceous: In the southern part of the concession where Flysch covers the formation, and along the north, western and southern edges of the Upper Cretaceous basin for stratigraphic accumulations.

2. Lower Cretaceous: Accumulations may be found on the flanks of the diapiric plugs.

3. Jurassic: Oil has already been found at Audignon anticline, and there are other possibilities of accumulations in wedging of sediments on flanks of the plugs.

4. Triassic and Permo-Triassic: In the northern part of the concession.

Most of the structures found by surface geological or geophysical means have been drilled with one or more wells, although the condition of equipment or shortage of materials has led to failure of some of the tests to reach depths thought to be conclusive. However, interesting results have been obtained in many cases, and enough wells have been drilled to arrive at some conclusions. Showings have been found in several wells outside of the one recently completed at Audignon, among which was a substantial show of gas in a well drilled on the Garlin anticline southwest of Audignon. It had reached 7980 feet when gas and salt water cut the mud to a point where part of the hole was lost through mechanical difficulties. The well is once more making progress and is now sidetracking to core back to the horizon where the gas was found. The 1948 program also includes at least one additional well on this prospect.

At Antin, near the western border of the RAP concession, a well was carried to 7800 feet in the Triassic, finding it underlying the Upper Cretaceous unconformity at that point.

Gas showings similar to those at Garlin have been found at Saint Medard in a well which topped the Triassic at 5100 feet, and which is still drilling below 7600 feet.

The deepest test now drilling on the concession is on the flank of one of the diapiric plugs at Bastennes-Gaujacq near an important surface seepage. It is now below 10,050 feet in the upper portion of the Lower Cretaceous formations encountered at 9930 feet. No showings have been reported but valuable information is being assembled.

More wells are planned for this year, including tests on some of the prospects already explored with one or more wells, but where results indicate need for more drilling. Altogether, the projected program calls for drilling about 42,000 feet this year, with the plan calling for a concentration of available rigs on first production found, thereafter assigning only one or two rigs for exploratory drilling.

At the present time the company has five heavy rigs available for drilling wells in the range of 6000 to 10,000 feet. Three of them are American rigs, one of which is now 13 years old and which will have to be retired for a general overhauling after completion of the well it is now drilling.

One of the remaining rigs is a German outfit brought in at the time of the occupation to exploit the RAP concession. The other is of French manufacture, made during the war and using pumps of German origin. Another rig available belongs to a contractor, who is being retained to drill 30,000 feet of hole.

There are also some light rigs for drilling to around 3000 feet, including two made in France and a portable rig used for testing. The light rigs were used on the Peyrehorade structure in the southwest corner of the concession where some indications of oil were found while drilling for potash.

Since travel to the U. S. has been possible, eight engineers and two toolpushers from the concession have visited American fields to study latest equipment and drilling techniques and a number of representatives of American manufacturers and service firms have visited the concession, including fishing specialists, mud engineers and testing technicians. The visits were arranged through the Institut du Petrole in Paris. Other Americans, including several tool pushers, have been in charge of the Drillers School at Audignon which has used the Audignon well as a means of speeding up training of drillers and pushers.

ACKNOWLEDGMENT

The cooperation and assistance furnished by the management of the SNPA in Paris and Touluose is gratefully acknowledged, and the writer is particularly indebted in this respect to L. Cauchois, tchnical director at Toulouse.

Guatemala OIL LAW

Likely to Retard Exploration

By Staff Representative

A NEW petroleum law, which very likely will continue to stymie the development of possible oil production in Guatemala, was announced by the government in an official document March 2. Passed last November, but which for reasons unknown was not made public for months later, the law came as a surprise to many who had anticipated a workable oil regulation which would have given impetus to exploration. Why the delay in announcing the law or how it escaped public knowledge so long is a mystery.

The new law came at a time when a number of American oil companies and individuals were becoming interested in exploring Guatemala's oil possibilities and when at least one company, Sohio Petroleum Company was reported to have geological or geophysical work under way in the Peten area.

More than two years ago Max Thornberg, formerly with Standard Oil Company of California, during the war a petroleum advisor to the U. S. State Department, and at present a consultant on petroleum laws, was engaged by the Guatemalan government to prepare suggestions for a petroleum law. This work he did. But the law announced March 2 changed a number of the Thornberg suggestions, omitted others, and included provisions not contained in the Thornberg proposals.

Provisions of Law

Briefly, the provisions of the new law are to the effect that a company or an individual may make application for a concession which, if granted, calls for the expenditure of at least 20 cents per hectare (2.47 acres per hectare) on the concession area, per year, for exploratory work.

However, an exploitation concession must be secured before development work may be undertaken, and when the company which has been operating on an exploration concession asks for an exploitation concession on the land it has explored, it must provide the government with all the information it has developed (though not its interpretations), which information is then made available by the government to any other concern which wishes to bid at auction against the explorer on an exploitation concession on the area already explored. Theoretically, the original explorer gets the concession if nobody bids a higher price than it does, but the law is so worded as not to make this mandatory, thus leaving the field open for special dealing with government officials! If the owner of the exploration concession is not the successful bidder, then the successful bidder must reimburse him for the money he spent in exploration plus 6 percent interest, and allow him 3 percent of such oil as may be produced on the concession. As written, such a provision would retard rather than accelerate exploitation.

The government royalty is set at one-sixth, but the holder of the concession pays an annual rental of 60 cents per acre for the first five years, the rental increasing even further as time passes, and the total life of the concession is limited to 50 years.

A pipe line concession and a refining concession may be obtained by successful producers—one provision is to the effect that a company discovering oil must build a refinery when the production reaches 2000 barrels per day, and unless it can show cause to the contrary, may be forced to build a refinery on developing 1000 barrels per day production.

However, the law very plainly says that its operations may not be in conflict with Section 95 of the Constitution of Guatemala, the second paragraph of which reads:

> "The deposits of hydrocarbons and its derivatives may be exploited only by the State, Guatemalans, or by Guatemalan companies whose capital is predominantly national."

The law goes even further in forbidding foreign capital the right to explore for, or develop, the petroleum resources of the republic through a "third party."

With the law as plain as it is, the question naturally arises as to how a foreign oil company could possibly develop Guatemala's oil resources, if, as remains to be proved, the republic has any. The unofficial explanation offered WORLD OIL, is that the government can contract with a foreign company to develop its oil, receiving five-sixths of the oil for the service, but the law is so written as not to make any provisions for such contractural relations, and in fact is written strictly from a concession standpoint.

Promising Area

The area in Guatemala which seems to hold the greatest promise from an oil standpoint is the Peten region. (See *The Oil Weekly*, July 1, 1946, page 9, International Section.) In this area three concessions are now in effect, with many applications, principally from Guatemalan citizens, pending.

The Compania Petroleo del Peten, S. A., composed of some Guatemalan citizens and three or four Americans, holds a concession in several blocks totaling 597,000 hectares. This is, of course, an exploration-type concession. The land lies principally north and west of Lake Flores, extending almost to the Mexican border. It is understood that part of this concession has been sold to oil interests in Texas.

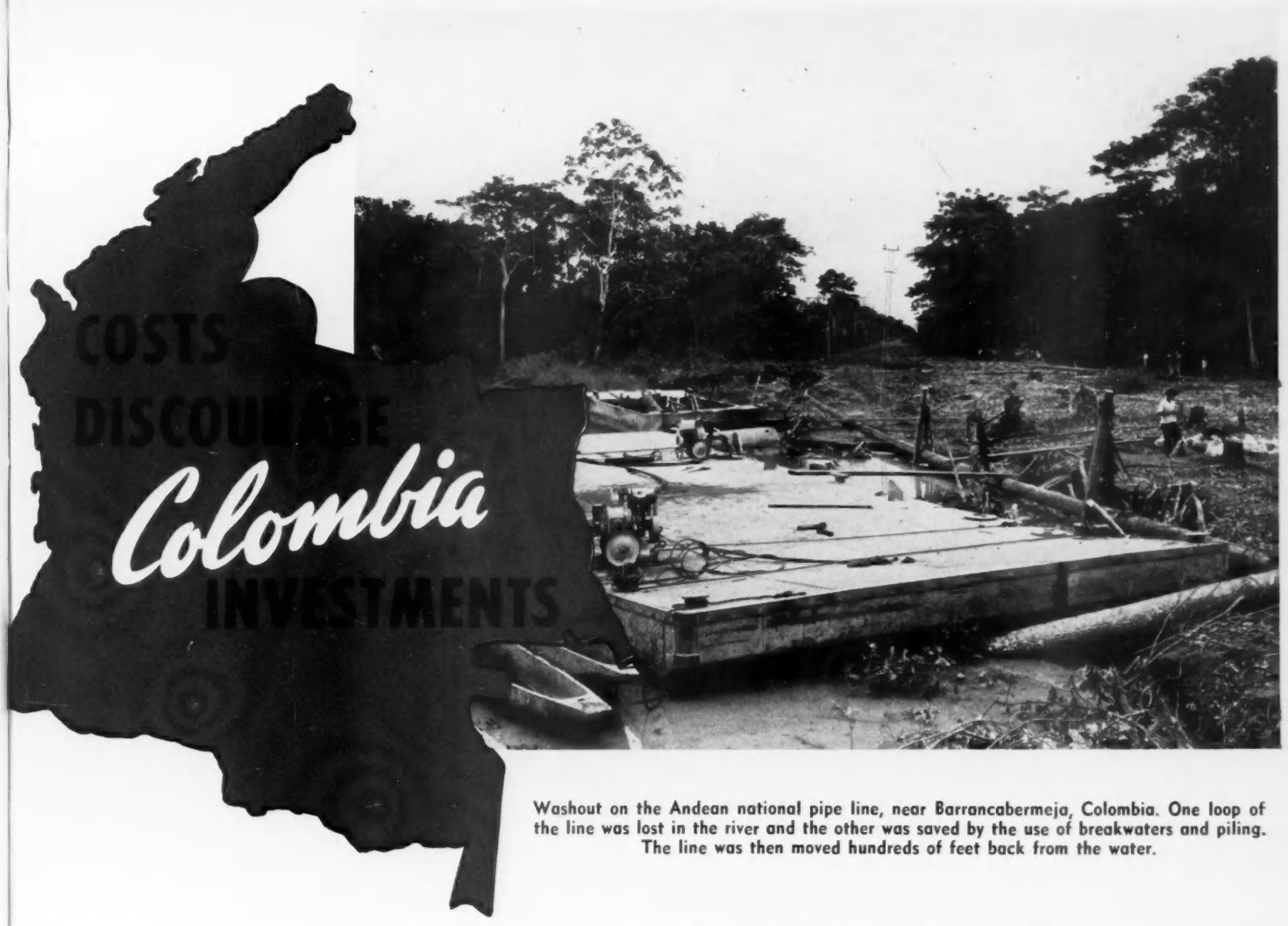
Stapper and Osborn, S. A., a firm composed of Americans, holds a concession on six blocks totaling 799,920 hectares. It is on this concession that Sohio is doing exploration work.

Dorion Bros. holds a concession of 140,000 hectares which includes all of Lake Izabol and El Golfete plus land west and north of Lake Izabol.

Should oil be found in the Peten area (much of which is covered by jungle) its logical outlet would be to the Gulf which lies directly east. This, however, is expressly forbidden by the new law.

Both Shell Oil Company and Standard Oil Company (N. J.) have previously done exploration work in Guatemala. Both concerns stopped their work several years ago.

Translation of the new law may be had from WORLD OIL for $5 per set.



Washout on the Andean national pipe line, near Barrancabermeja, Colombia. One loop of the line was lost in the river and the other was saved by the use of breakwaters and piling. The line was then moved hundreds of feet back from the water.

COSTS DISCOURAGE Colombia INVESTMENTS

By GEORGE O. IVES, International Editor

ALTHOUGH the search for new sources of production in Colombia continues, with six companies running 14 rigs on exploratory wells, there is a definite slump in total activity, and during the course of the last year the number of rigs in operation has been reduced. The general feeling is less optimistic than during the first year and a half after the war.

Strangely, this attitude seems to have been caused less by indifferent success of the exploratory program than by a feeling that perhaps the oil likely to be found might be a liability rather than an asset under current conditions. All present sources of crude production in Colombia are in areas which render transportation difficult and expensive. By the same token costs of development and supply have been more expensive than expected. Under the best of normal conditions the investment of great sums of money in such operations is a risk. Under conditions which have been gradually developing over a period of years it is becoming hazardous in the eyes of many operators.

Colombia has a considerable area which may be considered favorable oil territory. It is likewise no secret that costs of operation have risen beyond the mere increases in costs of material and foodstuffs. Not only have labor costs risen, but companies have, in addition, been called upon to bear other expenses of economic betterment of employes until actually, the basic salaries paid to workers is little more than half of the direct cost of labor. This does not take into account the losses in efficiency and losses in productive work per man-hour by labor organizations for which the oil companies seem to be the special target through work stoppages and threats of stoppage. For the most part, it must be admitted, the unions have held stoppages of work to the bare maximum number of hours off before complete violation of contracts may be charged against the workers.

DESPITE the existence of much unexplored oil territory, a slump in Colombia activity is likely to be more than seasonal as foreign operators become discouraged at mounting costs which seem disproportionate to the risks involved. Several had announced retrenchment plans even before the situation became aggravated by the current wave of labor trouble.

However, with increasing persistency during much of 1946 and 1947, the oil companies were attacked in the press and even from the floor of Congress, as "Foreign oil companies that exploit the very life and blood of the Colombian workers . . . " "Yankee imperialism," and talk of "nationalization of the petroleum industry," has been heard from the same sources. This idea was being more and more firmly planted in the minds of the Colombian people who, as is the case in the U. S., for the most part know practically nothing of the real problems and huge investments of the oil operator, and would be amazed to hear the small and sometimes non-existent return on such efforts and investments.

Tropical's Report

Toward the close of the year Tropical Oil Company made a public statement

on a decision it had been some time in making. It was planning an immediate reduction of its investments in Colombia. Troco has the most widespread interests of any oil company in Colombia. It is the largest producer of oil and supplies all but a negligible quantity of the country's refined products requirements, has an extensive sales and distribution system in operation, operates the nation's first pipe line, and holds huge areas under exploration concession. For years it has maintained a policy of adding to its investments, and of joining with private Colombian capital in various ventures. In making this annoucement the company went into some detail as to its reasons for such a decision, and as the news began to sink in there developed in the minds of the thinking public a realization that perhaps the companies, who were spending at least $2 million a month more than the value of oil they were taking out, might not be willing to continue spending at this rate as long as a hostile atmosphere continued in certain political and labor quarters. The industry is spending more than $5 million monthly and up to the time of announcement of possible retrenchment, the total value of exports was only $3 million. The entire difference is going into the search for oil, and with the exception of fields discovered some years ago, no new areas of commercial value have been found. Tropical is the only operator which has made a profit at any time, and this amounted to 1.4 percent in 1946. With the increase in prices of crude oil during the latter part of the year, the loss per month has been reduced somewhat.

Tropical has indicated that its decision will in no way affect the producing operations of the De Mares concession, nor will it affect its supply of refined products for consumption in the country, but will be principally concerned with the search for new fields. Whereas it was spending about $15 million in Colombia in 1947, it expected now to spend less than half that sum in 1948, or close to $7 million. In fact, regarding De Mares, the company is putting into effect secondary recovery operations from which it can hope to benefit very slightly before the concession reverts to the government in 1951. It is also starting on a program of construction which includes spending more than $200,000 during the next two years for workers' habitations.

It was pointed out that almost every company operating in Colombia is spending money and living in hope of future return, but that during the first six months of 1947, the latest period for which figures were available, practically all operators showed a substantial reduction in the amount of funds brought into the country for carrying on their operations. Although no action was taken on the new petroleum law, its provisions as proposed are thought to have an unfavorable effect on attraction of new exploratory operations through increased costs of obtaining and holding concessions during the exploratory period, and increased costs during the early period of exploitation.

A feature of the new bill, which would impose an ascending scale of surface taxes on concessions during the exploration and commercial period is intended to promote early development of any discovered oil fields, but surface taxes during an exploratory period would tend to raise costs of finding oil. The bill failed of passage, however, and it will not be considered again until July, when the next regular session of the congress is scheduled.

After drilling a dry hole on the Chaviva concession in the Llanos area east of the Andes, Tropical announced that its wildcat activity for 1948 would not include any work in the Llanos regions but would be carried out in the Magdalena Valley and other areas where transportation of possible oil discovered would not be prohibitive. It indicated that a pipe line from the eastern part of the Republic to a seaport would cost $100 million, and oil would have to be found in great quantities, with the prospect that such a line would have to operate at capacity for many years before even the original investment were recovered, not including the cost of finding and developing the oil. In recent statements it has been pointed out that in former years when construction was much cheaper than now, about $50 million was spent before the first barrel of Colombian oil arrived at the Mamonal terminal.

Troco has not been alone in its avowed intention to reduce investments. Socony-Vacuum Oil Company has announced a 1948 budget of only $2½ million, a reduction of 64.5 percent from the 1947 outlay of $7 million, and far below the $10 million spent in 1946. This company also has indicated unsatisfactory progress in its exploratory program, which was quite vigorous in 1946 and 1947. Failure to find oil in sufficient quantities plus increased costs have begun to force the same decisions on it as on other operations. It is estimated that one company, engaged in an operation of trying to develop a small field to commercial extent, experienced a loss of $2½ million as a result of one labor strike.

Labor Trouble

Further labor trouble now plagues Colombian operators. A strike has closed operations completely on the De Mares Concession, includes some wildcat drilling wells. Following clear statements to the public and all interested parties of the virtual cessation of drilling in the concession through having drilled up the fields completely, the company felt obliged to retrench and laid off 107 out of 3815 employes on the property. A strike was called immediately and labor judges at Barrancabermeja ruled the strike legal. The decision was rendered within two hours after the strike was called without the company being heard, and despite its violation of the law as certified by the Labor Ministry. At latest report the strike had been in effect more than seven weeks at a substantial loss to the company and substantial royalty losses to the government. A six-point compromise solution was offered by government conciliators and accepted by the company, but was rejected by labor union heads. It is understood that no referendum was made to the workers. Among demands of the union is complete reinstatement of the 107 discharged workers, with pay, and it is also understood that all workers receive a flat payment in cash on returning to work. Another firm demand of the unions is stability of personnel and salaries of Tropical until August 25, 1951, when the De Mares concession reverts to the government.

Following the De Mares strike which started on January 7, other companies have experienced similar difficulties. Workers on the Barco concession have gone on strike for other reasons, and further trouble was in store for Shell following that company's discharge of labor union heads and constant agitators. In this case the local labor court held that Shell's action was legal.

The fact that these disturbances are merely part and parcel of general situations recently arising in other industries in Colombia gives very little comfort to oil companies operating at costs verging on prohibitive.

A detailed study recently revealed that the oil worker, whose base salary is higher than that of any other industry in the nation, receives other benefits, paid directly by the oil companies, to such an extent that the base salary constitutes only 57.18 percent of what might be termed his total income. The extras are in the form of savings in food and clothing prices, housing, medical attention for workers and families, bonuses, overtime pay, time paid for sickness and holidays, transportation, education, life insurance, and many other items. All of these are furnished at a direct cost to the operating company, and any of these would normally be paid out of a worker's base salary. These costs are constantly rising since many items of food, available to employes in commissaries at prices frozen several years ago, are still purchased by the company at current prices.

Tropical Oil Company bulk plant on the Magdalena River, Barranquilla, Colombia, and line which carries oil from barges to tank farm.

This pegging of prices cost one company alone more than $500,000 last year.

Other companies are sustaining similar losses, and the net result of all these increased costs is that the companies are wondering if it is wise to plan additional investments for an uncertain future. Until a new oil law is on the statute books it is difficult to estimate conditions under which concessions will have to be operated.

Talk of possible nationalization, though mostly from sources not connected with official circles, has given additional reason for hesitation. A bill was before the recent congress for the establishment of a Colombian YPF, a government oil company to operate the De Mares concession when it passes to government ownership on expiration of the concession contract in August, 1951.

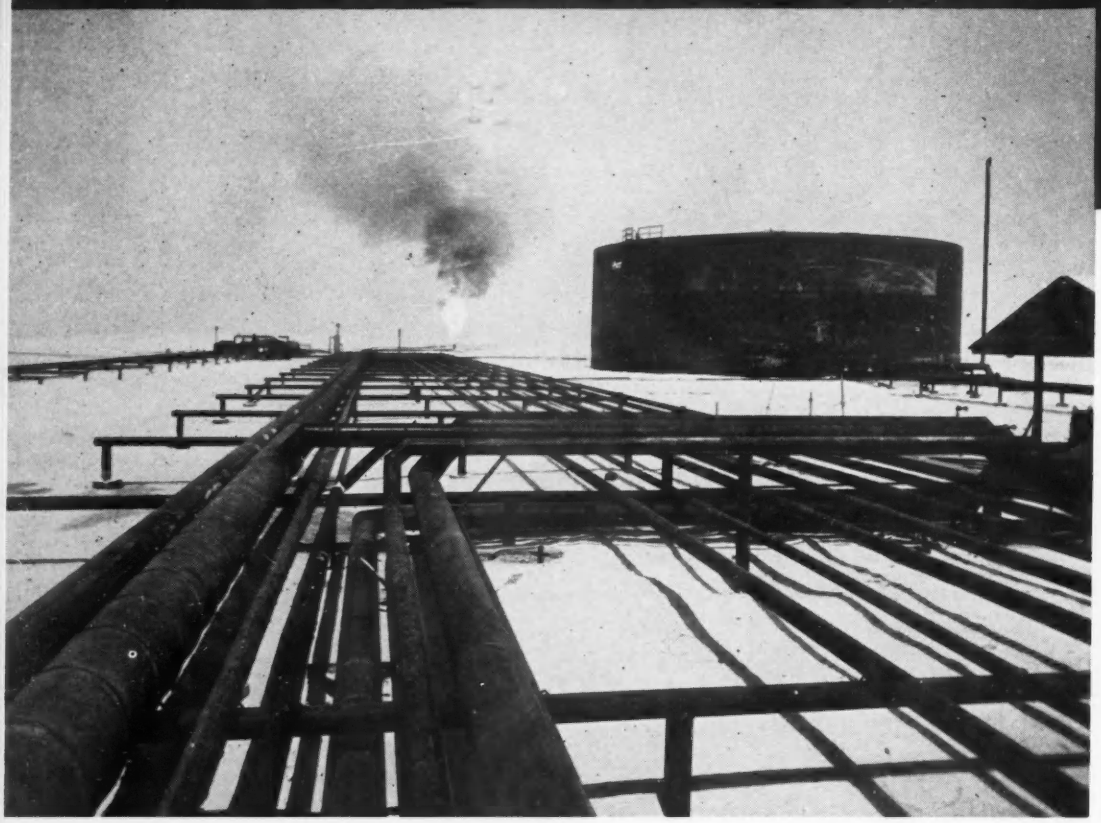
Socony-Vacuum Oil Company, which connected its Cantagallo field to the Andian Pipe Line in December to go into the 30-year exploitation period of the concession, has apparently decided against continued operations on the expanded scale of a year ago. The Cantagallo field has only four wells capable of production, and unless unlooked-for expansion takes place it is doubtful whether this field will return the investment required for its discovery and drilling. Its expected rate of production from the four wells is only about 800 barrels daily. Only one wildcat rig is being operated by the company now, in addition to part interests in operations by other operators. The budget for 1948 apparently contains no plans for operations other than those now being drilled.

Shell is operating only two exploratory rigs, both of which are in the Llanos region where it has been obtaining noncommercial showings during the past few years. This company has steadily increased its production from the Casabe field and is in not too bad a position. Casabe, which went on production the middle of 1945, is now producing 14,000 barrels a day, approximately 18 percent of Colombia's total production. Shell's field at Dificil in the Lower Magdalena Valley is to have a pipe line outlet and will go on exploitation with 15 producers in the field and two rigs running. The line should be completed this year.

To other companies, Colombian operations still represent all investment and no return. The Texas Petroleum Company, with completion of its second well on the Teran-Guaguaqui fee south of De Mares, has improved its position somewhat, but still must do a great amount of development work before the field is proved to be important enough to justify the expense of building a pipe line outlet. Meantime, its other operations are of a nature involving more than usual expense. A proposed wildcat in the Caqueta region of extreme southern Colombia will require building of an entire base camp on pontoons and keeping it supplied by air, using amphibian planes. At the time the company completed its discovery on Teran-Gaugauqui it had spent more than $25 million in Colombia and had not marketed a barrel of oil.

In pointing to increased costs as partial reasons behind its decreased budget, Tropical presented figures to show a comparison of oil production per worker employed. In 1945, the date for which complete figures were shown, Colombia's production of oil per worker employed was only 1524 barrels a year. In Venezuela at the same time there were 10,410 barrels produced per worker, while in Mexico the figure was 2347 barrels per man per year. With all costs higher, Colombia oil is approaching the point where its production will not support a substantial exploratory campaign unless oil is found in substantial and producible quantities at costs allowing at least a small return on the investment over and above what is paid to the nation in royalties and taxes.

Pipe Line Bottleneck Curbs SAUDI ARABIA Output



Pipe lines feeding Ras Tanura refinery.

SAUDI ARABI, expected to become one of the major Middle East sources of crude to help supply unprecedented world demand, was the scene of steady operations during 1947, and the beginning of 1948 found Arabian American Oil Company holdings in an encouraging state of development. Operation of seven drilling rigs in 1947 resulted in 24 completions, and pipe line construction completed is more than capable of transporting present production to Persian Gulf shipping points.

The greatest limiting factor now to greatly expanded production is the lack of a transportation outlet directly to the Mediterranean, such as the proposed Trans-Arabian Pipe Line which was designed to deliver from 300,000 to 350,000 barrels of crude daily to Mediterranean ports. Work had been going ahead steadily on the preliminary construction phases of this line until the political situation arising out of the proposed Palestine partitioning made it advisable for the time being to concentrate work on the Saudi Arabia sector. Recent developments in the Middle East have caused concern on the part of military experts as to whether it is advisable to continue shipments of steel to the Middle East for such a pipe line, or to allocate additional steel to tanker construction. Secretary of Defense Forrestal said in the latter part of March that a decision would be reached before the end of the month as to which course should be taken from a broad point of view.

SAUDI ARABIA operators, actually ahead of schedule in producing potential to meet their share of unprecedented petroleum demand, may be forced by current Middle East political considerations to abandon plans for the pipe line to the Mediterranean. This would constrict production increases to what can be moved by tankers.

Late in the month it was believed in Washington circles that in view of the United States reversal of the stand on partitioning it is entirely possible that Forrestal's announcement may indicate a decision by the military to go ahead with the pipe line plans.

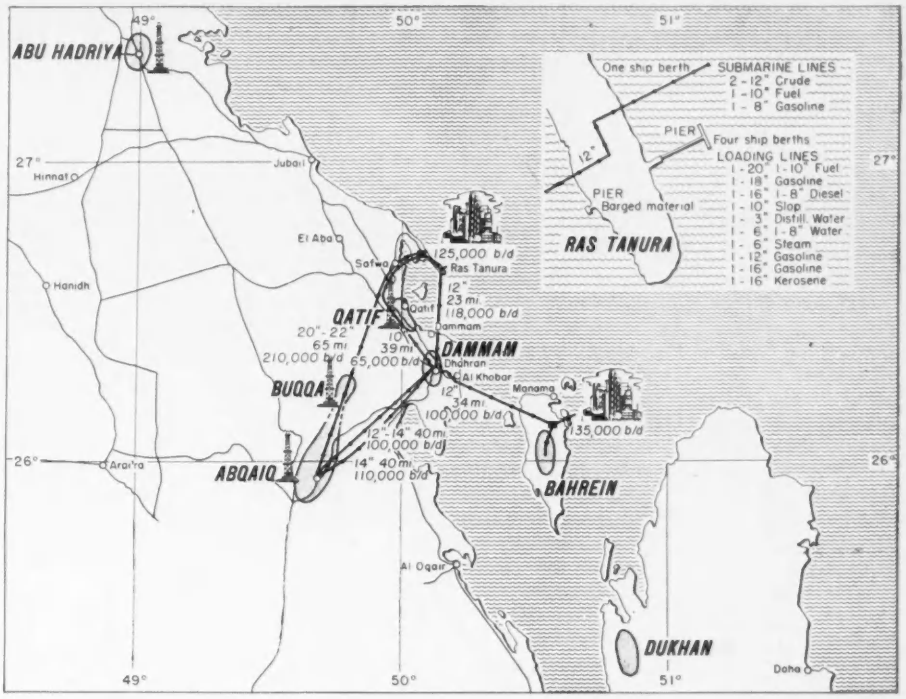
United States abandonment of partitioning plans is said to have caused a change in the attitude of the Syrian gov-

ernment, which might now be ready to go ahead and grant transit rights previously withheld.

Meanwhile actual construction has been started on the first part of the line, comprising some 160 miles of 30-31 inch pipe connecting Abqaiq to Qatif Junction on the Persian Gulf coast and extending on up to Abu Hadriya, so that any increased tanker availability would find outlets provided to a Persian Gulf port whether the line were extended on to Sidon, Lebanon or not.

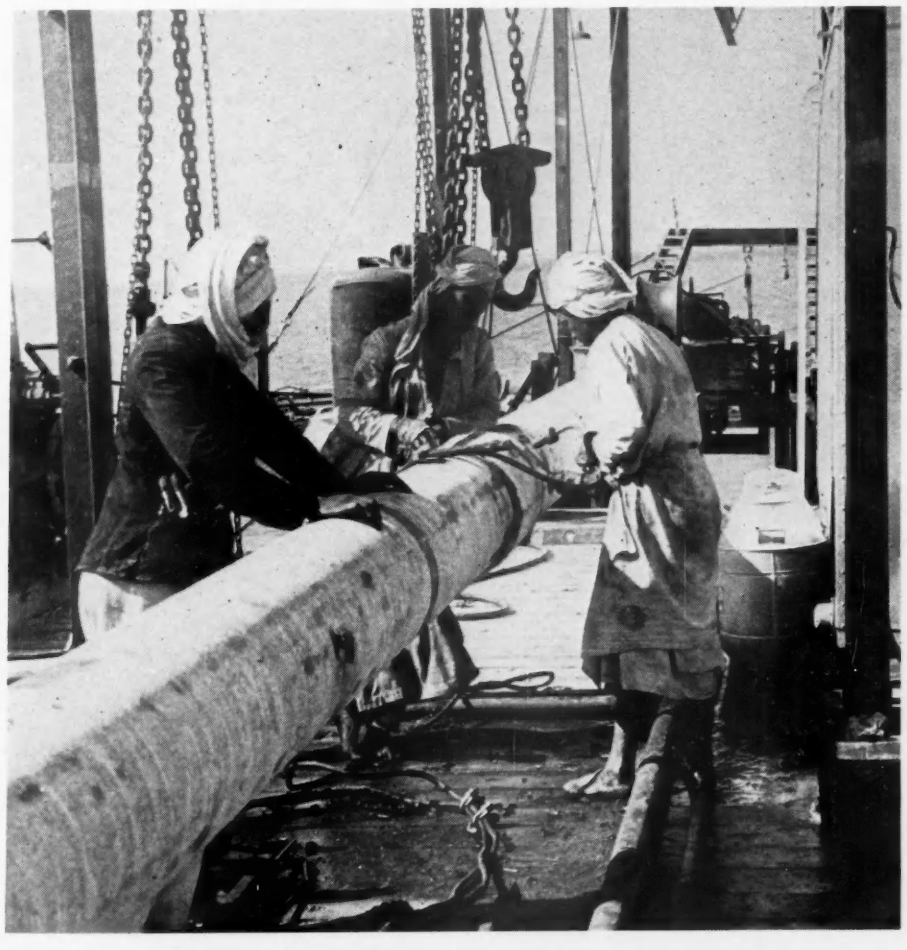
A pipe-jointing plant had been completed at Ras el Misha'ab, equipped for automatic welding of 30-foot line pipe joints into sections 90 to 150 feet long, and work had progressed very near completion on additional facilities for unloading and handling the expected tonnage coming in to the pipe line base camp at Ras el Misha'ab.

An interesting action of ARAMCO during 1947 was the decision to surrender a portion of its preferential rights to territory not already under firm concession in Saudi Arabia. The part surrendered is all of the acreage under this classification lying west of the 46th meridian and represents all but a comparatively small part of that originally held. The release of these rights does not in any way affect the 440,000-square mile concession now held under firm contract. The company did not enlarge upon its statement that these rights have been released.



Petroleum facilities of Saudi Arabia, Bahrein and Qatar.

In addition to starting construction on some phases of the new Mediterranean Pipe Line project, a new outlet has been provided for the Abqaiq field, apparently the most important of the discovered fields of Saudi Arabia. The line, a 40-mile, 14-inch carrier from Abqaiq to Dhahran, has been placed in operation, is capable of transporting 110,000 barrels daily to the shipping port, and increased the capacity of the field outlet from 100,000 barrels daily at the end of 1946 to 210,000 barrels a day at the end of 1947. However, production of the field has already been brought to approximately that figure and it is apparent that still another line would be needed. A combination 30-22 and 20-inch line to connect Abqaiq with the Ras Tanura, site of the big refinery, has started building. Route of this line will take it through the new Buqqa field to furnish that area with its first outlet, and when completed it will have a capacity of 300,000 barrels daily. It will bring to a total of 698,000 barrels daily the capacity of local lines to move crude to Persian Gulf ports. The operators apparently feel that water transportation will be available to move this quantity of crude from the Persian Gulf alone.

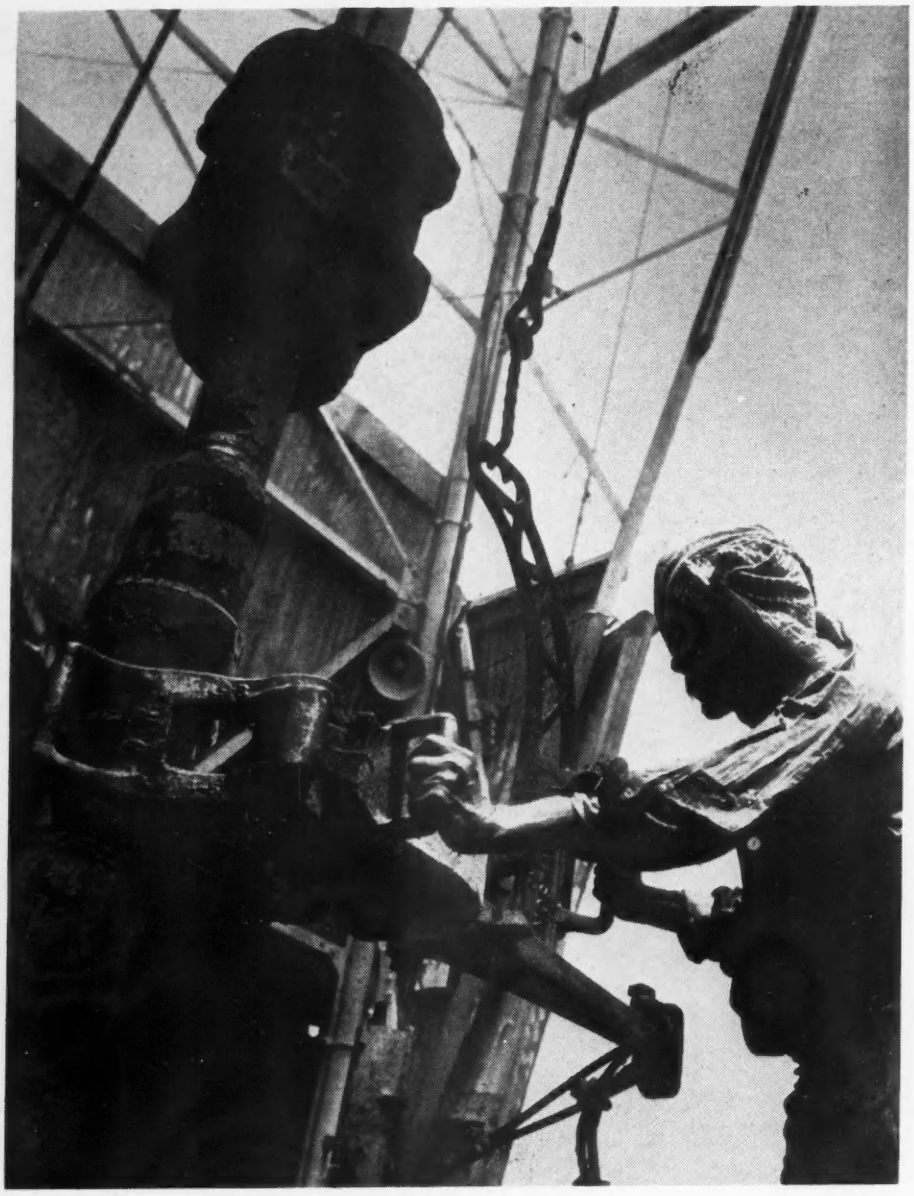


Twelve-inch pipe line between Saudi Arabia and Bahrein Island.

Early in 1948, production from Saudi Arabia alone had been increased from 214,675 barrels daily at the beginning of 1947 to a current production of 305,000 barrels, of which 200,000 barrels are being drawn from Abqaiq. Actually, a number of the field's 27 wells have not yet been connected by pipe line, and present output is from about 15 wells.

New Field

One of the most important developments of 1947 was the indication in April, of a new field northeast of Abqaiq, known as the Buqqa area. As was indi-



Drilling in Saudi Arabia.

cated by WORLD OIL at the time this well started drilling, its general characteristics, structural position and evidence of previous geological work made it possible that it would prove to be on a portion of the same structure as the Abqaiq field. Three wells have now been drilled, and the drilling information strongly indicates that Buqqa is actually a northeast extension of Abqaiq. The discovery was drilled to 8520 feet before being plugged back for completion in Arab lime at 7243 feet, running substantially level with pay in the Abqaiq field as well as with the Qatif field to the northeast. Proved is a pay section 220 feet in thickness which also compares favorably with Abqaiq. A fourth well is now being drilled, and is so situated that it will determine whether the area is part of Abqaiq. Establishment of this field as a part of Abqaiq with connected reservoirs would greatly expand the proved reserve of the area.

The greater part of the drilling activity of the year was concentrated in developing Abqaiq, with 18 wells drilled on the structure, one of which moved out far enough on the east flank to finally establish a water table. The test does not produce but is being retained as an observation well. The other 17 were oil wells, some of which have been connected into the production system while others await completion of the new pipe line. These wells, together with the three drilled at Buqqa, constituted the bulk of the drilling activity, the others being one well at Dammam and two at Qatif. No further drilling has been done on the Abu Hadriya structure where the one well remains shut in since discovery in 1940. Development has been concentrated in other areas because Abu Hadriya is more remote from present refining and shipping facilities, and is producing from much greater depths than the other fields. The Hadriya lime from which it produced was topped at approximately 10,000 feet, nearly 3000 feet deeper than pay is found in other Arabian fields.

Other Improvements

In addition to field development for the building up of potential, much work has been done on other facilities incident to drilling, producing, refining and transportation of crude and products. By elimination of certain constrictions in method of operating the refinery at Ras Tanura, its capacity has now been increased to 115,000 barrels a day. It previously had been rated much lower, but before the beginning of 1947 had reached an operating level of 100,000 barrels a day.

A power station has been started to serve the Abqaiq-Dhahran area. It will be in the Abqaiq field, where construction has already started on a new crude oil stabilization plant. The crude from the field has a relatively high sulfur content, but lends itself readily to stabilization.

As had been announced previously as a proposed activity, ARAMCO has already started work on a railroad from Dammam to Abqaiq by way of the town of Dhahran. While this will furnish needed transportation facilities for movement of oil-country material and supplies between the two points, it is at the same time being made available to the public. Work has likewise started on construction of a new pier and seaport facilities at Dammam, facilities which are also to be made available for the use of the country as a whole. The present plan is that eventually the railroad and port installations will be owned and operated by the Saudi Arabia government.

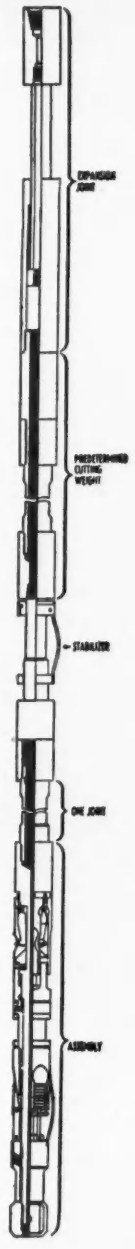
Extensive additions were made in 1947 to the building program in the various operating and base areas. New housing for all classifications of employes was built, as well as office, shop and industrial facilities.

The American staff in Saudi Arabia has now reached a total of 2500 including employes of American contractors working for the company, and Arab employes now number approximately 12,000.

Recently, with the outbreak of violence in Palestine, and pending looked-for agreements on transit rights across Syria, the Trans-Jordan and Lebanon, the Trans-Arabian Pipe Line Company shifted most of its personnel back into Saudi Arabia so work on that end could go on unabated, which it did until the recent announcement by Forrestal. About 875 miles of the proposed 1075-mile route lie within Saudi Arabia itself. Since pipe is actually being laid on the Abqaiq-Qatif leg, no real delays will have been suffered should decision be made to go ahead.

NUMBER 4 OF A SERIES

POINTS TO LOOK FOR WHEN CHOOSING FISHING TOOLS



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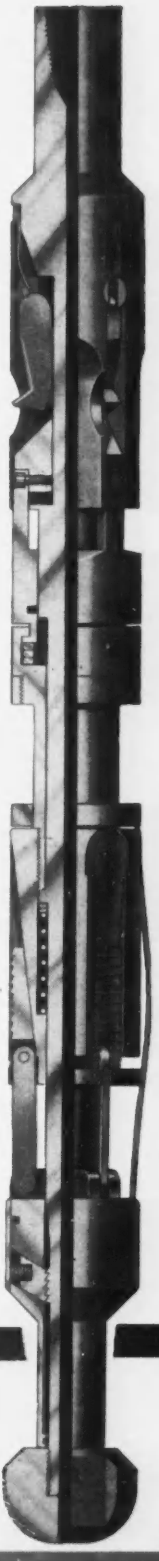

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STRATEGIC VALUE OF MIDDLE EAST OIL TO U.S. Overemphasized

THE direct strategic value of Middle East oil for the U. S. has been greatly overstressed, according to Bernard Brodie, associate professor of international relations at Yale University who has just written a monograph entitled "American Security and Foreign Oil." The work is published as Foreign Policy Report No. 24 by the Foreign Policy Association, Inc., of New York. Dr. Brodie was professor at the National War College during World War II and is the author of several books on military strategy.

Dr. Brodie contends that while the U. S. so far has furnished the major part of the world's oil, "its ability to continue to do so, or even to meet its own needs, is about at an end. The most obvious alternative source of supply is the Middle East." He then analyzes strategic and economic difficulties in the Middle East petroleum development program and concludes, "If we were to become dependent mostly or even largely on such an area as the Middle East for our supplies of oil in wartime, we would be accepting an enormous handicap. For regardless of where on the globe military operations had to take place, our primary concern would have to be with protecting what might easily prove to be a tenuous line of sea-borne communications from the Middle East to our own shores—a line which except for our dependence on oil we might have no military interest in maintaining. Even that proposition assumes that the area in which the oil originates remains out of enemy hands. The fact is, that for the U. S. the Middle East is one of the most insecure areas of the globe."

Difficult to Defend

Whether it is possible to defend the Middle East oil fields in war is not the issue, says Dr. Brodie, but the proper question is, "Whether the oil itself or its denial to the opponent would be worth the price required to defend it. So long as any feasible alternative remains, the answer must almost certainly be 'no.'"

The "almost," he explains, is contingent on whether the alternative is available at a lesser price in manpower and physical resources, and whether there are other objectives within the area the defense of which has so high a priority as to carry the petroleum objective with it.

"The strategic approach to the oil problem," says Dr. Brodie, "must be based on the premise that so long as it can be made to fulfill our basic wartime needs, the only oil reserve worth defending is that which can be held with a minimum of defensive military commitments. Since the U. S., the Caribbean and the northern part of South America clearly fall within our "minimum strategic defense area," a sound strategic oil policy must stem first of all from an accurate appraisal of reserves within that area, both of crude petroleum and of alternative sources of liquid fuel."

Dr. Brodie argues that the distinction between "domestic" and "imported" petroleum may be misleading because "while trade statistics consider all petroleum resources outside the U. S. as foreign, from the strategic point of view those situated in Latin America or Canada are available—with qualifications—to a degree comparable with domestic resources." The qualifications with regard to South American sources, he says, are (1) availability and vulnerability of transportation; (2) the oil policies of Latin American countries which may be subject to no influence from our own government. However, he holds, as long as petroleum is being produced in Northern South America it is likely to be available to us in military emergencies.

When shortages of material and equipment are corrected, the report says, "Middle East oil production will be limited only by the available market or by possible threats of grave political disturbance such as might discourage the influx into the area of further venture capital."

Economic interests, Brodie admits, "would dictate a policy of encouraging American nationals to develop further the immense petroleum resources of the Middle East.

"It is likely that large integrated producers will always seek to hedge their riskier foreign holdings with substantial domestic holdings and activities. But as American production and especially American exploration costs continue to rise in comparison with those of the Middle East, as they are bound to do, we should expect a slow tapering off of American production and eventually a situation where even the largest market was supplied predominantly with foreign oil.

"Under such circumstances the better American fields would certainly continue to operate profitably, although on a gradually diminishing scale. The American refining industry, too, would continue to flourish and possibly even to expand, though it would tend to grow more dependent on foreign rather than on domestic crude production. Wildcatting would naturally tend to diminish in the relatively unpromising areas at home and would be encouraged instead to migrate abroad."

Such a siutation, Brodie argues, even though it would relieve strain on our own oil reserves, has disturbing elements in it. "Oil in the ground is not necessarily oil available for war. The building up of large proved reserves takes many years. "From the strategic point of view, the drawback of the program outlined above as most advantageous economically is that, unless qualified by special measures, it would put our domestic oil production on a liquidating basis as concerned proved reserves. For the activity which would be chiefly discouraged by

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Aramco Takes to the Air

Five new planes, with their special Aramco paint jobs, waiting shipment to Saudi Arabia, where they will be used by Arabian American Oil Company for pipe line patrol and light transport duties.

By C. B. COLBY

ALWAYS quick to obtain and use the latest devices as aids in the perpetual search for more of nature's "oil tanks," the petroleum industry is more and more turning to aircraft. From the complicated technique of locating underseas oil-bearing strata with the new magnetic airborne detector, to the simple use of aircraft as personnel and freight craft and for pipe line inspection, the airplane has established itself as an item of "must" equipment in the industry. An experienced and highly enthusiastic user of aircraft in the huge business of oil is Arabian American Oil Company.

Aramco has quite a fleet on its payroll (19 planes in all) and an aircraft operating personnel staff of more than 200 experts.

Operating out of that 1½ million square miles of sand, camels, sand, century-old cities, sand, mountains, sand, Arabs and more sand between the Red Sea and the Persian Gulf, known as Saudi Arabia, Aramco began operations back in 1930. It came about as a very natural outgrowth of an invitation from King Ibn Saud to American experts to seek oil in his sandy kingdom. With typical Yankee impatience, the Americans enrolled aircraft to help in the search—with February, 1947, making the real coming of age of aircraft in that land of the camel and shifting dunes.

Since then, Aramco, owned jointly by The Texas Company and Standard Oil Company of California, has increased its fleet of aircraft to a size where it is larger than the air force of many smaller countries. It is one of the largest privately activated "air forces," the latest addition being a fleet of five single-engine, four-passenger units for high speed courier service, and pipe line inspection. Others in the fleet include two four-engined transports, one a rough-and-ready cargo job and the other a strictly "plush" affair for company personnel; eight twin-engined transports, two single-engined, four-passenger transports; one twin-engined transport; and a ten-passenger single-engine plane. This fleet of 19 assorted aircraft has been assembled with an eye to ease of maintenance, service, and performance.

World-Wide Air Arm

The fleet is not limited in operation to the company's holdings in Saudi Arabia. On the contrary it is world-wide and is a "king-sized" operation requiring the experience of veteran airmen with a desert know-how learned the tough way instead of from training manuals.

The "CO" of this Aramco fleet is E. S. Maloney, chief pilot of The Texas Company and a veteran ATC pilot with plenty of desert flying experience. It's his chore to keep the fleet ready at a moment's notice to fly anywhere, anytime and with almost any type of cargo.

There are 8 pilots, 10 co-pilots and 200 or so trained mechanics, servicemen, weathermen, and instrument experts to keep the equipment rolling. All of the airmen are Americans.

Flying in that piece of the globe has its own problem and many of them are pretty knotty ones, even for the experts. The climate itself does anything but cooperate, ranging from spells of freezing weather to periods to 130 degrees in the summer months.

Aircraft engines as well as the airframes themselves take an unmerciful beating the year around with the metal hides and wings hot enough to cook lunch upon—even a Christmas dinner. The heat also cooks out other items of vastly more importance to Chief Pilot Maloney—the planes' oil, insulation and instruments. Metal parts of the aircraft and their interiors become almost untouchable except when in the air, and tires in particular find the heat almost too rugged to take. Then there's that little item of dust.

So fine is the talc-like desert dust that no filter has been devised to stop its entrance into anything except a solid piece. Cameras, watches, instruments and engines all are vulnerable and must be

taken apart and cleaned often. Cameras have to be dismantled and cleaned each night before they can be used the following day. Engines inhale it as a matter of course, making it possible and routine to scoop handfuls of it literally from the oil sumps after a few hundred hours. An occasional rainstorm blasts the dust down, but being usually of short but violent duration, complete with hail and all the trimmings, they are of little dust-laying value throughout the year.

Driven by the north wind during the summer months, the desert sand rises in choking blinding clouds to a height of several hundred feet, above which is the dust "fog" continuing on up to nearly 10,000 feet, where the turbulence takes over to make up for the clear air. Maloney declared that safety belts are a "must" for it is usually so rough at this altitude that it is difficult for a pilot to stick in his seat, to say nothing of flying the aircraft. This dusty mantle of the desert makes navigation by contact an almost impossible technique, except along the coast where the air is clearer or inland when occasionally the pilot can follow the pipe lines snaking across the sands. Arab tents of black-dyed material vanish at a thousand feet and check points in the desert just aren't.

Landing Fields

The shifting sands, held back by miles of snow fence, make landing fields a continually temporary matter, except where old AAF fields are still in use. At Dhahran, for example, there are excellent accommodations for planes and their servicing. Two 6000-foot runways, hangars and shops mark this as the logical headquarters for the "fleet." Additional fields of the company are usually bulldozed out of the dunes, right down through the top sand to the hardpan below, and then surrounded with snow fences to keep the dunes from running back over the "field" with the next breeze. "Wheels-up" landings are the thing if no field is handy for a nose-over is routine in the soft sand unless it has been prepared for aircraft. Even the roads, plowed out of the talc-like sand, must be oiled and then held open with more of the snow fence.

The servicing of the aircraft omits only one detail—repainting. The only paint used on the fleet is for numbers and the ARAMCO along the sides, for the shifting, grinding sand burnishes the pigment off in almost a matter of hours. Bright paint for identification is useless for even the brightest pigment vanishes into the haze at a few hundred feet—as a matter of fact, the bright metal of the planes is far better for spotting among the dunes than any color yet devised.

All the aircraft and flying personnel are under the control of the CAA (Civil Aeronautics Administration) for they must be certified to fly to or in the U. S. at any time on a moment's notice. This primarily is for the benefit of the larger craft, for two round-trips a month are scheduled from the U. S. to Saudi Arabia and back with high priority cargo and key personnel. It's a 30 hour ride via Newfoundland, Lisbon, and an occasional "way station."

All the aircraft of the fleet, including the latest additions are equipped with the best of blind flying instruments, navigation equipment and extra tanks, which can be installed for special assignments. The planes carry water and food when on long flights across the dunes, for the desert can be as cruel as the North Atlantic to a hapless downed airman.

The miles of pipe lines writhing across the dunes no longer are a patrol problem. Instead of days of checking via Arab employes trekking along the line through the glaring heat and dust, hours will suffice for the same patrol—hours in a comfortable speedy plane, in constant touch with the home base by radio. Leaks may be spotted and reported in a matter of minutes, and a repair crew dispatched before costly leakage really gets under way. The cost of operating the Aramco fleet has been more than offset by the oil losses prevented from this aerial "herd riding" on the long lines, and the time saved in obtaining badly needed parts and key personnel from distant points.

Although the weather, dust and work are all rugged, it is not all too tough for the personnel to take. The pay is good, living quarters modern and attractive, and there is plenty of opportunity to save money for the time when an employe's 30- or 60-month contract ends. The buildings are air-conditioned. There are schools, movies, swimming pools and recreational facilities for the American personnel. Even trees, soil, and the flowers and shrubs that grow in it were shipped over to make everything as home-like as possible—and then there is plenty of flying for the fleet crews.

Already the mainstay of our Naval fuel oil supply in the Far East, Aramco's future is bright in promise for becoming a leader in the oil industry—as bright as the sand burnished wings of its air fleet, through whose operation much of this promise is coming true.

Middle East Oil

■ CONTINUED FROM PAGE 226

a vast inflow of cheap petroleum from abroad would not be the production of those of our richer fields which are already proved and developed, but our domestic exploration. Production would diminish only gradually, but the rate of discovery of new fields might decline quite drastically. The net result would be the rapid diminution in our fund of proved reserves. Under those conditions a new war emergency would find us totally unable to fill our oil needs from American resources."

If American demand is forced to rely predominantly on American production, that will stimulate the most thorough kind of domestic exploration, Brodie says, but it, too, has certain disadvantages.

"To promote domestic exploration by increasing, or at least maintaining the rate of consumption of the domestic product, is like trying to lengthen a rod by adding to one end while whittling away the other. Also such a system would make the large-scale availability of secondary sources contingent on relative exhaustion of primary sources."

Way Out of Dilemma

All this presents a dilemma, Brodie concludes, the solution of which calls for a judicious choice among various alternatives. "It is clear that Middle East oil is by no means without strategic significance to the U. S., but in a different way from what has generally been assumed.

"The case for a strong American position in support of American nationals interested in developing and exploiting the oil resources of the Middle East has been admirably and eloquently stated, on predominantly economic grounds, by at least one State Department official (John A. Loftus). His statement understandably plays down American strategic interest in the same pursuit, but we know from other observers of the policy-making machinery that strategic conceptions of a more or less random character have greatly influenced the policies in question. There is no reason why economic considerations should be unaccompanied by strategic considerations and vice versa, so long as there is a minimum of confusion between them. The real strategic importance of Middle East oil depends on how its exploitation affects the availability of domestic (i.e., Western Hemisphere) resources and facilities for large-scale production of liquid fuels. In other words, strategic policy concerning the Middle East oil is meaningless except in terms of the comprehensive domestic oil policy which is designed to supplement it."

DEVELOPMENT OF Foreign Oil RESOURCES by

Drilling well in Salta area, in terrain typical of much of Northern Argentina.

J. E. BRANTLEY, President, Drilling and Exploration Company, Dallas

TECHNICAL SKILLS in finding oil, and a high degree of efficiency in development, transportation and refining are requisites for successful domestic operations. But there are many additional basic factors involved in developing resources in a foreign country. These are discussed in the accompanying paper, delivered at the annual dinner of the Petroleum Division, AIME, February 17.

THERE are four basic requirements and conditions which should govern the development of the natural resources of a given country by organizations, personnel and capital of another country. These may be summarized, broadly, somewhat as follows:

1. The nation within the boundaries of which there occur commercially workable natural resources must have the desire for or need the benefits to be derived directly or indirectly from the development of these resources or must wish or need to share these resources with other nations or peoples not similarly endowed; and further for reasons of lack of experienced personnel and capital is unable to procure this desired or needed development within the technical and financial resources of its own people.

2. There must be a national or foreign demand, or both, for the natural resources or the products of the resources and a possible profit to be derived therefrom which together create the desire of foreign organizations, personnel and capital to undertake their development.

3. Assuming the existence of these two conditions, there remain to be prepared laws, decrees and legal procedure and concessions, contracts or agreements, the terms and execution of which provide fair and reasonable participation by the owning nation and its nationals in the benefits to be derived directly or indirectly from the developments; and which provide likewise and similarly that a reasonable and fair proportion of the benefits to be derived from the developments shall accrue to the account of the foreign or expatriate operators and capital.

These requirements and conditions are equally applicable to the development of any resource of a given country by the efforts and capital of individuals or organizations foreign to that country. The resources and developments may be placed in three categories: First, those resources which are used or consumed wholly within the national bounds of the proprietor nation; second, those which are developed for use within the country and for export; and last, those which are developed and produced entirely for export. The scope of this discussion will be confined largely to petroleum and its associated natural materials which fall under the first or second category, depending, usually, upon the character and extent of the deposits and of the production developed.

Any area having considerable thicknesses of marine sedimentary formations offers possibilities for the production of oil in substantial quantities. Therefore, the lands of all states or nations in which these sedimentary areas occur should be and eventually will be explored and drilled for oil. The majority of these areas of marine sediments may be expected to produce oil in the future.

The boundaries of these nations, throughout the world, that were selected and established prior to 1914 were so described without regard to these sedimentary areas and to the possible occurrence of oil. Other resources and particularly arable lands were sometimes taken into consideration. The primary basis for the designation of these boundaries was the distribution of peoples and the topographic or geographic boundaries which limited the ready and easy movement of people and commodities of trade. Arbitrary or compromise boundaries likewise were chosen.

Petroleum and its products have been in wide use for little more than a gen-

eration or two and yet a substantial part of the known and assumed probable oil reserves of the world has been produced and consumed. Still, oil is of growing importance to all nations and to all peoples and none can develop culturally or economically, by modern standards, without a generous supply at reasonable cost.

With the growing dependence of all nations on transportation and power facilities for cultural and economic development, no nation with the possible exception of a few with small areas and dense populations can afford to purchase from outside sources all the petroleum products that it can and should use. Therefore, an entirely adequate petroleum supply depends upon its recovery from national territory. The U. S. consumes approximately 6 million barrels of petroleum daily, worth at the point of manufacture or of refining an average of $3 or more per barrel. This is a total of approximately $18 million daily or roughly $6 billion annually. The economy of this nation could not afford such an expenditure of resources and labor in exchange for any single commodity.

Probably the only nations in the world that consume all of the petroleum products that their economy and culture will permit are those within whose boundaries an exportable surplus of oil is produced. These nations are Venezuela, Colombia, Peru and the producing countries of Asia Minor and the East Indies. The U. S. left this category of nations with the commencement of World War II. It may or may not return. Even these can and will consume more with the expansion and development of their resources and wealth. Within these nations petroleum products are low-priced commodities, thus making them available to a greater percentage of the people than were the products purchased from foreign sources.

In practically all other countries of the world, with the exception of the U. S., petroleum products are relatively costly commodities due to handling charges from the areas of production and high duties, and therefore are available to smaller percentages of the people of the country than would otherwise be able to use them. Nor will the economy of any country permit the purchase from foreign sources those quantities of petroleum products that are actually required in order that its people may take fullest advantage of their usefulness.

Thus, all nations having petroleum resources within their borders need to have those resources developed in order that fuels and lubricants may be made available to their nationals at minimum cost and in order that they may spend resources abroad for the purchase of commodities which they do not possess. These nations also need the revenue which may be derived from sales abroad of their excess production. Those nations which do not have sufficient petroleum deposits within their boundaries have the moral right to have made available for their purchase and use that quantity that they can afford to purchase, and at a reasonable cost.

Despite the manner in which the national boundaries of most of the nations of the world were selected and despite the vast areas of non-petroliferous rocks, a surprising majority of the nations include within their boundaries sedimentary rocks which offer possibilities or probabilities of usefully producible oil.

The few nations of the world that are highly industralized have become so in very recent times, only a few score of years. With the exception of two or three countries of Western Europe, none has become so entirely through its own efforts

The extent to which a community has been mechanized largely governs the standard of living of its people. For this reason only is it important. A nation in which one horsepower is developed for each inhabitant has a very low standard of living. A nation in which 20 horsepower are developed for each inhabitant has a high standard of living. The ratio is direct, for all practical purposes.

It is extremely difficult for any nation or any people to develop a resource or build a plant or engage in an industry in which its people has had no experience, without assistance from the peoples of other nations who have had such experience. People who have had little or no experience in the use of capital in industries and the development of natural resources can not readily be persuaded to assign their funds to use in such hazardous undertakings. There is little venture capital except in those countries long experienced in financially hazardous undertakings.

The principal incentives for the group or nation to develop or to permit the development of a given resource are the need of the resource, itself, or its products and other benefits to be derived therefrom. The principal incentives for the individual are a means of livelihood, a profit or, simply, accomplishment.

The motives of the people and venture capital of the highly industrialized nations in exploring for and developing the resources of other countries are not altruistic, though they frequently serve the same end. It is their purpose to develop the resources for a profit to themselves, and this incentive is required by human nature, but in doing so they create a means through which substantial numbers of the people of the host country may earn a livelihood. They make the resource and its product available to the people of the country at reasonable cost and usually produce a surplus of the material or products that may be used by the nation in exchange for other materials or products that it does not possess or produce.

It is the duty and it is to the benefit of the older industrial nations, through men and materials and capital, to aid in the development of the resources and industry in a country that has not been so developed. This serves usefully the people in the country being developed and the commerce and industry of the country that is the source of the technical personnel and capital. Most important of all, it leads toward the eventual prosperity and peace, maybe, of the world. A people with an average pay scale or income scale of 25 cents per day can not as a whole enjoy more than a very low standard of living and culture. Nor are they buyers of the manufactured products by which high standards of living are made possible.

As already related, petroleum deposits are found in sedimentary formations that had their sources over vast continental areas. They were influenced in their deposition in marine waters and structural form by world-wide forces and phenomena. International law and custom require that the petroleum deposits thus formed and now found within the political boundaries of a nation belong to it. In most of the countries and dependencies of the world the petroleum of the subsoil belongs to the people as a whole. In the U. S., however, with the exception of government-owned lands and reserves, the petroleum of the subsoil belongs originally to the owner of the surface. That owner has the right to develop the oil himself or to contract its development to others.

In some of these countries where the nation holds title to the subsoil, which is administered by the government, the right to develop and produce is held entirely within the province of the government. In other nations which own the subsoil the right to explore for and develop the petroleum resources of the country are contracted or leased or given by concession to individuals or corporations of domestic or foreign nationalities.

It is the inalienable right and privilege of a sovereign nation, represented by its government, to choose the policy that it will pursue. If it elects to develop its petroleum resources through governmental agencies, it is quite within its moral and legal rights, and should receive the sympathy, support and assistance of those nations and peoples experienced and proficient in such operations.

On the other hand, if the nation elects

to develop its resources through the medium of individuals or corporations, it must then promulgate such laws that individuals or corporations have proper incentive to carry out exploration and development.

The obvious advantage to the nation in the development of its petroleum resources by its people through the medium of its government is that the nation has at all time full, complete and sole control of all of the oil produced and its reserves and that all the benefits to be derived accrue to the nation. By the proper use of trained and experienced personnel and proper training for use of its own nationals, such exploration and development may, theoretically at least, be carried out as effectively and economically as could corporate operations or those carried on by individuals. In effecting such an operating organization for exploration, production and refining and for normal efficiency, the organization must be established in a more or less autonomous position that is not subject to the vicissitudes of political control. It should function as nearly as practicable as would a normal private enterprise and it should be operated for profit as though it were a commercial venture. Only in this manner can the most efficient operations be conducted.

A people may decree that all of the natural resources of the nation included in the subsoil or on the surface other than the surface soil itself are the property of the people of the nation and are to be administered by the government of the people, but that the development, production and processing of these resources are the right and privilege of the individual separately or as they may be legally organized in corporate bodies. This privilege or right of development may be restricted to its own nationals or the privilege may be extended to other nationals in return for reciprocal privileges or in order that experienced personnel and capital may be enlisted in or seek the development of the petroleum or other resources of the country in question. The only one of these several conditions which need further discussion herein is that under which foreign capital is allowed to explore for and develop petroleum resources.

In the following discussions it will be assumed that a nation having a sufficient area of sedimentary beds in those thicknesses and of those types in which oil reasonably might be expected to occur in commercially producible quantities is desirous of having its prospective petroleum reserves explored for and developed by trained foreign personnel supported by experienced foreign capital.

As sole owners of the subsoil and the petroleum resources of the nation, the people as a nation have the right to and should receive their just proportion of the oil produced. They have the further right and duty to promulgate fair and reasonable laws governing the operations and activities of the operating organization. At the same time and in return for the hazards taken and for the service to the nation in developing its resources, the operator has the right to expect and receive a fair proportion of the oil produced and the opportunity to earn a reasonable profit on his investment. The laws promulgated should not restrict the operations and activities of the developing organization in such a manner as to impair the efficiency and effectiveness of the operations. Nor must they defeat the very purpose for which they were designed.

The petroleum law may be built around either of two basic principles: First, it may provide for the granting of concessions to operators who will pay to the government a percentage of the gross income of the oil produced or will assign to the government a percentage of the gross production recovered, at the election of the government. Second, the government may retain full title to all petroleum that may occur on a given property and enter into a contract with an operating company, paying to that operating company a percentage of the oil found and produced by it. In the first type, the company receives title to such oil and gas that might occur in the subsoil with the privilege of exploration and development as may be required. In the second, the government or the nation retains title to all its resources. The operator agrees to explore for and develop such oil that may be found within the limits of the area under contract to him, at his entire expense and be paid therefor in oil.

These two types of laws may finally arrive at identical ends, ownership and payment differences being of a technical rather than of a practical nature. The second, retaining in the nation title to all resources, may be more expedient politically.

Major Conditions of Law

After the basic principle of the law has been selected there are three major conditions to be written into the law. They are, first, the division of the petroleum either in kind or in income between the nation and the operator; second, the amount and distribution of the lands on which concessions or contracts are to be executed with the operator; and third, the amount and rate of exploration and development required of the operator by the government. Each of these three conditions may be divided into many subheadings. They will be discussed in basic principle only.

There is no proper and fair division of the oil or the benefits from it between the nation and the operator that is applicable generally to all areas and to all conditions. Despite this obvious fact most petroleum laws are based on the fallacy of the equity of uniform royalties. In finality, an operator is willing to receive as his ultimate part that proportion of the final profit from the venture that will justify the undertaking. The operator takes into account and the law should take into account the conditions which control the development of the property and the production to be obtained per unit of expenditure or operating cost.

For simplicity, the amount of the gross oil as such or the income from the gross oil accruing to the benefit of the government will be referred to hereafter as "royalty," regardless of whether the law is written on a contract or a concession basis.

It would be quite possible, theoretically, at least, to calculate a royalty scale that would provide a fair royalty to the government under the varying conditions which control exploration and development, even though these conditions are almost limitless in their number and effect. A few of them are distance of the areas to be prospected from areas in which the oil and its products are to be marketed; distance from the properties to pipe line or deep water transportation facilities; operating conditions in the areas to be developed such as desert country or rainy forests, hot or cold country; the amount of exploratory work that has to be undertaken before oil is found; the amount of development work that has to be done before oil can be marketed; the productivity of the producing formations to be developed or the amount of production to be obtained per well or per unit area; the rate of production per well or per unit area; the problems of production; and the drilling costs, including the depths of the wells. Many other conditions could be added but these are sufficient to indicate the vast complexity of the problem. It would be entirely possible to draw curves including all of these conditions that would permit the calculation of the proper royalty on a given property having once determined the basic value, but it would be utterly impractical to do so. It would appear then, that a basic royalty should be established throughout a country where the conditions are more or less similar or for each region of a country where conditions vary substantially from those of other regions.

In basic principle the royalty should be the minimum that reasonably can be expected by, or is acceptable to, the owning nation. The purpose of this low royalty is to create an incentive that

will induce operators to seek concessions or contracts to explore and develop the petroleum resources of the country.

In addition to these royalty provisions of the law, there should be clauses providing for division with the government of the net profit accruing to the operation. This percentage of division of profit should be graduated, based on the ratio of net income to gross development costs and operating expense. That is to say, a property that requires more effort and more capital and expense for the production of a given amount of oil should surrender a smaller proportionate part of its income than the property which requires a lesser effort and lesser amount of capital and expense for the development of its oil. As a further example, a development or a field or an area that can barely be developed within sound economic limits should surrender to the government a lesser proportion of its net profits than an area or field in which drilling costs, production costs and capital requirements are very low. Because of accounting difficulties, it would be impractical to create too narrow subdivisions, but the basic principle can be established and adhered to, as in the usual income tax law, to the advantage of both the host nation and the operator.

Only by the establishment of a minimum royalty and a fair and reasonable graduated tax on net income can the inequalities of a fixed over-all high royalty be eliminated and marginal deposits or reserves brought into useful production. Further, the governing law or the contract or concession itself should provide fixed terms and conditions that include total royalties, taxes and other imposts and requirements that would not be altered throughout the life of the agreement except as provided in the law without the consent of the operator.

Under such a petroleum law, carrying minimum royalty provisions and division of net income or an income tax calculated in accordance with a properly and carefully determined graduated scale, the nation would be assured of its fair proportion of all the benefits derived from the development of the producing properties and the operator would be freed of undue and unnecessary hardships and could generally conduct a more rational, orderly and efficient program.

The amount and distribution of the land to be assigned under each concession or contract depends on the amount of territory having possibilities of commercial production and a minimum area of lands for exploration that would justify the interest and undertaking by the prospective operator. As a matter of principle it generally would be advantageous to the host nation to allot lands to more than one or to several operators. The spirit of competition, the diversity of ideas and theories concerning the occurrence of oil, the diversity of oil-finding methods and technique, and the variety of operating practices will all be helpful to the primary objective, which is the recovery of maximum oil at minimum cost.

The final major point or condition to be determined is that governing the exploration and development program in so far as time is concerned. Here a balance must be sought between the requirements of the government for oil and income and the time requirements of the operator for thorough exploration and efficient development. Here again the natural conditions will control to a considerable extent. If the country is open, accessible and has easily-workable geology, a minimum time for exploration will be required. As it decreases in accessibility and as the geology becomes more difficult, an increased exploration period is essential. Development should come in an orderly manner, determined by the requirements for the oil and economics. It is difficult to fix such matters by law because of rapidly changing conditions. Therefore, broad terms and conditions only are practical, and adjustments and changes that are necessary to meet new conditions should be agreed upon and caused to function by both the host nation and the operator within the spirit and basic principles of the original law or contract.

Action taken by the host nation under its powers to make laws or issue decrees that alter the terms and conditions under which either national or foreign operators accepted the responsibility of exploring for and developing such oil that might be found, tend to defeat the basic purpose for which the laws were designed. At the same time, abuse by the operator of technicalities and liberal privileges under the basic laws are immoral and tend to force the government of the host nation to exercise its sovereign authority in correcting such abuses.

Summary

All sedimentary basins on the several continents offer possibilities for usefully producible oil. The majority of the nations, states and dependencies on these various continents, with the exception of Africa, include sedimentary basins within their boundaries. All of these areas eventually will be explored or drilled for oil and the majority of them reasonably may be expected to produce.

There are no nations, with the exception of two or three highly industrialized small countries, which can afford to purchase abroad all the petroleum products they require for their desired cultural and economic development. Therefore, in order that they may attain and maintain that standard of living for their people which petroleum products can promote, the sedimentary areas of possible production must be explored and developed for the primary benefit of the nation.

The phenomena which gave rise to the present accumulations of oil in commercial quantities were worldwide in their scope. The boundaries of nations which include these deposits within them were selected without regard to these resources. The boundaries of those nations that do not include sufficient petroleum resources were similarly selected. The nations of the world that do not have petroleum production and can not produce their requirements have the moral right to have petroleum products made available to them at reasonable prices consistent with the cost of the delivered products. Even then the burden of purchasing sufficient lubricants and fuel for maximum economic and cultural development will be more than most of these "have-not" nations can bear.

A nation having within its boundaries known or prospective deposits of oil has the inalienable right to select the manner in which these deposits shall be developed. The nation may elect to have its petroleum resources developed entirely by governmental agencies, with or without the assistance of trained foreign personnel. If this is the course the nation elects to pursue, it should have the entire sympathy, assistance and support of other nations and other nationals.

If the nation elects to open the development of its resources to foreign personnel and foreign capital as well as to those of national origin, then it should build laws that will serve with fairness and equity both the nation and its people and the foreign guests who have been invited to undertake exploration and development. If the nation wishes to pursue this course successfully, it may not construct laws that defeat the purpose for which they are designed.

The personnel and capital foreign to the nation in which they are employed must bear in mind constantly that they are guests of a foreign people and that they may not presume upon their positions as guests beyond the limits of those fair and courteous practices which are mutually acceptable and advantageous. Nor may they remove the natural resources of the host nation without balancing compensation of a material nature or otherwise.

In finality, contracts and agreements will have been entered into between honest and honorable people. The actions of all concerned should be governed accordingly.

Germany's Stepped-Up Exploration

Yields Little New Oil

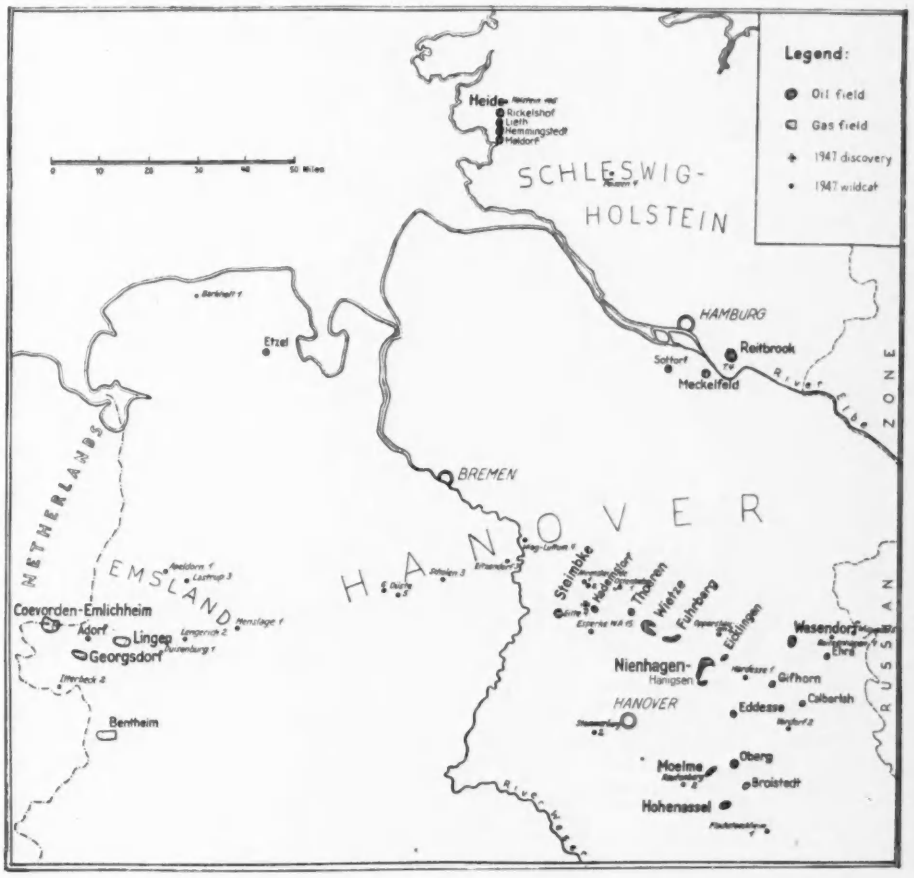
GERMANY'S exploration program during 1947 showed a sharp increase over 1946 activity, which in turn increased substantially above 1945. The accelerated activity resulting in completion of 28 wildcats during the year is additional evidence of Germany's attempt to establish a reserve to make itself self-sufficient, although it has a long way to go.

Practically all oil activity is concentrated in the British and American zones of occupation and almost all of this is in British-occupied Northwestern Germany. At the present time only one exploratory well is drilling in the American zone, although the Americans and British are cooperating in sponsoring the development in the entire oil area.

Although wildcatting was carried out in each of the principal producing sectors of the country, results were none too encouraging from the standpoint of finding new fields, with only one well . . . in the Hanover district . . . being productive, and this probably will prove noncommercial.

The principal value from the exploratory program was in establishing new deeper producing zones in some known fields, and extending others to include new reserve. Promising oil and gas showings were found in wildcats in the Hanover and Emsland districts, but in each of these areas additional drilling will be necessary to establish whether or not commercial oil deposits actually can be located near the wells which had the showings.

During 1947, total footage drilled in Northwestern German fields amounted to 348,776 feet, or nearly 25 percent more than 1946 drilling results. A significant feature is the increased percentage of exploratory drilling as compared with previous years. Exclusive of development wells and extension tests, the German industry drilled 142,197 feet of hole in exploration work, or slightly more than 40 percent of the total footage drilled. In 1946 exploratory work of this type amounted to only 76,046 feet, or 29 percent of the total footage drilled in that year. Attainment of this high drilling rate represents somewhat of an achievement in view of the difficulties in obtaining materials and equipment of all types.



Wildcats in Northwest Germany during 1947.

The search for oil in Germany is somewhat risky for investors because of the nature of deposits, and it is becoming more apparent that the brunt of exploratory work must be borne by larger operators. Although the search for oil through the past 20-year period has led to the discovery of a considerable number of producing areas in the region of Lower Saxony and in Schleswig-Holstein, the nature of these discoveries has necessitated considerable investment to reduce them to producible form. As a general rule the existing geological conditions in Northwestern Germany permitted the accumulation of deposits of relatively minor extent, not to be compared with fields in some other producing areas of the world; therefore, from an international point of view, they are of lesser significance except as the nation shall develop them to the fullest to help its internal economic situation.

Largest concentration of wildcatting has been in the Hanover district, a region of salt-dome structures which includes 18 of Germany's 26 fields. Nineteen of the 28 wildcats drilled were in that area, and it was there that the strongest indications of new discoveries was noted. Three wildcats were drilled in the Schleswig-Holstein region which includes Hamburg, and six were in the Emsland area in the extreme west, where best hopes for future production lie in development of the anticlinal structures being worked out.

Several prospective salt structures are in the Russian zone adjacent to the

eastern part of the Hanover district, but there has been no exploration on them during the past couple of years. Drilling equipment and plants in that area were dismantled and moved to the east, and no drilling was possible. Reports from Germany indicate that no change is expected in this situation.

The American zone has only one exploratory well drilling at the present time, started in 1947. It is being drilled by the Deutsche Erodel A.G., leading German producer to date, in Upper Bavaria about 24 miles south of Munich. Exploration in the general area has been carried out for more than ten years, but had slowed down since no encouraging results had been obtained in a number of deep tests. However, recent development in the Austrian Vienna Basin have stimulated interest in this area and it will doubtless receive more drilling.

A significant well was a deep exploratory test on the south flank of the Reitbrook oil field in the Hamburg area, where Reitbrook T-4 was drilled by Preussag and Deutsch Vacuum. This was considered important to the whole area in testing possibilities below the Zechstein salt, since the sub-saliferous Middle Zechstein is productive in the Heide fields. The normal production in this field is from a lime horizon in the Upper Cretaceous at 2100-2600 feet and a lesser sandy pay in the Eocene on a deep-seated salt dome. It had encountered high gas pressure in anhydrite while drilling at 9652 feet in October, 1944, and had to be shut down because of lack of proper pressure control materials. From the time the blowout preventer and surface fittings arrived in September, 1946, until August, 1947, the well drilled on down to 10,020 feet, delayed by fishing jobs and other mechanical trouble, reaching the Zechstein salt just above total depth. A string of casing has been set to 9992 feet and production tests are in progress now with nothing definite learned. Both of the other wildcats in this general area have been drilled on salt uplifts without result, and at present a core-drilling program is in progress in the tidelands area near Meldorf, the most southerly of the Heide fields. One of them, Holstein 146, north of the Heide area, and two miles from production, had some gas shows, but no indications of oil.

The most satisfactory results of German drilling during the year were in two wells, not wildcats, drilled as extensions to the Wesendorf field. One established the deepest production yet found in Germany, and the other extended the southern limits of the upper pay more than a mile. Wesendorf is the largest poducer of the Hanover group of fields, accounting for approximately 58,000 barrels a day from 18 flowing wells. Discovered in 1943, it has previously produced from the Dogger sand only, but Wesendorf 27 was carried on down to a new horizon from 5970-6070 feet and completed in the Lower Liassic for an initial production of 280 barrels of 41-gravity oil daily. Not only is it the deepest production found in the nation, but it is also the lightest oil now being produced. Wesendorf 22-B proved that the productive area of the upper horizon extends for more than a mile past previous production on the southern flank of the dome.

Deutsche Vacuum drilled Eilte 4 between the Steimbke and Hademsdorf fields during the year, opening a potentially productive area through having produced, during the testing period of several months, about 600 barrels of heavy oil. However, it finally went altogether to salt water, and it is problematical whether ensuing wells will establish real production. Another well is now being drilled which should throw some light on the area. The oil-bearing sand was found in the Upper Wealden sand below the overhang of the Eilte salt dome, and final depth of the well was 4219 feet.

Shallow Showings

Farther east, exploratory drilling is being done in the vicinity of the town of Celle, where shallow wells on an anticlinal structure north of the Neinhagen-Eicklingen salt domes showed some traces of oil. In some of the holes drilled by Gewerkschaft Elwerath, good showings were found in the Wealden and Valendis sands as shallow as 460 to 820 feet, and deeper structures may find such accumulations under more impervious overcover.

Between Neinhagen and Gifhorn the Deutsche Erodel A.G. drilled Hardesse 1 to 6299 feet, finding promising oil showings in the Valendis, Wealden, Coral Oolites and Dogger Beta formations, but the hole was finally lost after a series of mechanical troubles. A production attempt made in the Dogger was thought inconclusive due to damaged casing and unsuccessful cementing and sidetracking jobs. A second location is to be made 3300 feet to the northeast where seismograph surveys indicate the crest of the structure should be. The second test should clarify the subsurface picture, and it should be possible to make satisfactory tests of the horizons which showed oil in the first wildcat.

Slight amounts of oil were recovered on tests of Valendis sand at 1158 feet in a wildcat drilled by Preussag between the Calberlah and Oberg fields. Some structure was proved in drilling this well below 2500 feet, and results justify further drilling.

The Emsland district, regarded as most likely to be productive with completion of more exploratory work, has not yet received as full attention as desired by holders of concessions in that district, due to shortages of both labor and materials. Only six wildcats were drilled in the district, and interesting showings were reported in two of them. These two areas will likely receive more drilling during 1948.

Most likely area is along the Dutch border, where Itterbeck 2 was drilled on a concession belonging to C. Deilmann, Gewerkschaft Elwerath, Preussag and Wintershall. The well is near the crest of an anticlinal structure and was abandoned in October of last year at 2520 feet after having showings in the Muschelkalk-Bunter horizons of the Jurassic. Production tests recovered 20 to 25 barrels of heavy oil in four days but failed to establish production in this well.

Gewerkschaft Elwerath, Deutsche Vacuum and others drilled a wildcat on the Apeldorn concession northeast of Emlicheim which had shows in both the Wealden and Serpulit in the upper Jurassic in drilling to 1887 feet. Other wildcats in Emsland were dry, deepest having been the Menslage 1 which went to 5689 feet.

Indications are that Germany will continue its stepped-up search for new oil through 1948, since under the present financial arrangements it will no longer be economical to resume the production of gasoline from coal at twice the cost of imported gasoline. Further, German synthetic capacity has been reduced by Russian dismantling of some of the largest plants in the eastern zone.

London Area Wildcat Finaled With Gas Showings, No Oil

D'Arcy Exploration Company's wildcat in the Willesden Area, London, has been completed at 3680 feet without finding production. It reached the Upper Devonian formations at the depth, consisting largely of mudstones and silts with thin limestone and quartzitic sandstone streaks. Minor indications of gas were found, but there were no shows of oil. Another test is planned for the Portsdown area in Hampshire near the site of a dry hole drilled in 1936. It is scheduled to the Wealden, Purbeck and Portland formations.

Plans are under way by the Department of Geophysics of Cambridge University to start a gravity survey in the English Channel during May, employing help from a submarine. Object of the survey is to cover the area from Plymouth to Hastings to obtain information regarding the structure of the English Channel to assist in interpretation of the geology of Southern England in relation to that of the Continent.

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Mexico

Offers 'Glorified Drilling Contracts'

MEXICO arrived at March 18, the Tenth Anniversary of expropriation feeling that nationalized operation had failed to maintain its oil resources, and that it needed the benefit of American technology, experience and capital to bolster reserves. Under Pemex no substantial new reserve has been discovered. There had been considerable conjecture as to how Mexico would approach a situation where foreign companies might be dubious about risking capital without guarantees, and still justify its actions in a nation favoring nationalization. It is not thought that the proposal described in this article is the answer from the American operator's viewpoint.

MEXICO has at last made known the conditions under which it will readmit foreign petroleum companies to operations within its borders, and the restrictive character of the terms has caused intense resentment on the part of industry leaders who have been made acquainted with the policy and on the part of several government officials. The conditions for the re-entry of American oil companies into Mexico have been set forth in a document handed by Antonio Bermudez, head of Pemex (Mexican government oil monopoly) to U. S. Ambassador Thurston. This document has been regarded as "top secret" in Washington and has been circulated to only a very few industry leaders for comment. Their reaction unanimously has been unfavorable, most of them viewing the terms as nothing more than a "glorified drilling contract."

The conditions:

1. Pemex will designate the areas for exploration and development for all American companies operating in Mexico.

2. The American oil companies must supply all required capital, equipment, facilities and skills for work undertaken.

3. Pemex reserves to itself the right of supervision and management over operations and approval of all budgets.

4. If no oil is discovered by the American operators, the total loss of the venture is to be borne by the companies.

5. If oil is discovered, all expenditures for geological, geographical and drilling activities shall be returned to the American companies up to 80 percent, from the sale of oil after deductions of operating expenses and taxes owing to the Republic of Mexico. After such deductions, the companies would receive 10 to 15 to 20 percent of the value of the sale of the oil.

The Mexican policy is particularly vitiated by Pemex' insistence into all contracts negotiated of the "Calvo clause." This specifies that the American oil companies agree not to have recourse to the diplomatic protection or intervention of the U. S. government under penalty of forfeiture of their operating rights.

Pemex did not clarify whether these conditions were applicable to all foreign companies seeking participation in Mexico's oil development program, or whether they are special terms for the American companies only. This is one question on which the American industry asks specific clarification.

The Pemex terms have caused a flood of protest among top industry leaders to whom they have been made known. The complaints center around three chief objections:

1. The legality of the contract is questioned. To one American company this is the chief stumbling block, since it doubts that Pemex has authority to enter into any such type of relationship.

2. Management, under Pemex' terms, does not lie with the companies, but is vested in Pemex itself. Most of the American companies are firm that they will not re-enter Mexico unless they retain the control of their own operations in their own hands.

3. The profit arrangement is unsatisfactory. The Pemex terms are contrasted with Venezuelan conditions where a 50 percent participation is provided. Industry leaders point out that the Pemex terms are comparable to those of Venezuela up to the point where the companies reach a profitable operating stage, but decidedly inferior thereafter.

Despite the protests of the American industry, several representatives of the State Department are known to consider the Pemex offer "a starting point." One State Department official said: "This is only a bargaining basis; undoubtedly the terms can be bettered in actual negotiations." Other industry members are not so certain, and are inclined to believe that the Pemex offer would be the best arrangement American operators could hope for. If that were true, it is conceded that small, independent American companies might agree to such stipulations, but it is considered unlikely that a major company would be interested in so entering Mexico. The "Calvo Clause" is regarded by many State Department officials as mere "window-dressing," dismissed with the comment, "No American citizen can sign away his national rights." Industry officials, however, point out that such an interpretation would provide no security against an American operator being canceled out at any time by Pemex.

India's Geological Survey To Be Greatly Expanded

A plan to expand the Geological Survey of India to more than five times its prewar organization was revealed in a recent statement by N. V. Gadgil in reply to a question in the Dominion Parliament. The purpose of the expansion is to conduct extensive research for minerals with the help of modern instruments and methods.

The sections recently created in the Geological Survey of India for that purpose, are the Geophysical section, the Drilling section, the Mineral Development section, and the Rare Minerals section.

It is also proposed to create a Bureau of Mines to act in an advisory capacity for production, conservation and utilization of minerals in the country.

Another step consists of efforts made for increasing the technical manpower in the country by reorganization of the Indian School of Mines, Dhanbad, by implementing the recommendations of the Geological Education Committee, and by sending abroad on scholarship and on deputation officials and non-officials for higher education and training in mining, geology, geophysics and allied subjects.

The Geophysical section, which was inaugurated in the middle of 1945, has been strengthened by further recruitment.

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STURDY, SIMPLE CONSTRUCTION

The assembly of Baker Model "B" Casing Centralizers (Product No. 910) consists of only three kinds of parts—Collars, Springs, and Stop Rings. Two Collars (positioned at each end of the Centralizer) hold the Springs in place and space them properly. The Collars are *not attached* to the casing, and the Springs are not welded to the Collars. The Springs are held in position by spacer lugs having slots or notches between them, and the turned down ends of these lugs hold the Springs in place. The Springs, which bear the brunt of the load, are formed with a hook at each end, and are made of 3/16" by 1½" spring steel, shaped in a bending die and heat treated to secure ample strength combined with maximum flexibility.

Stop Rings (one at each end) are the *only* parts of the Centralizer attached to the casing, each Stop Ring being plug-welded to the string at four points. The ends of the Springs are hooked over the Stop Rings, and Springs and Collars are left free to turn on the casing.

SAFE, POSITIVE OPERATION

Figure 1 (opposite page) shows the Stop Rings (1) plug-welded at (2) to the casing, with sufficient space left between Collars and Stop Rings (at 3) to permit the maximum elongation of the Springs, even if they were compressed tight against the casing.

Figure 2 shows the casing being run into the hole with the lower Stop Ring engaging the hooks on the lower ends of the Springs (4) and PULLING the Centralizer through the hole (or casing)—NOT PUSHING it through. When a restriction (5) is encountered, the Springs *compress uniformly* and elongate in an upward direction, moving the top Collar towards the upper Stop Ring (6). During the downward travel of the casing, the upper Stop Ring is never in contact with either the Collar or the upper hooked ends of the Springs, so that this upper Stop Ring is unable to exert on the Springs any PUSHING force that would tend to buckle or distort them.

If the casing has to be raised for any reason, the above action is reversed, and the Centralizer assembly is PULLED (rather than PUSHED) *up the hole* and past any restriction.

You will find the Baker Model "B" Casing Centralizer illustrated and described on Pages 366 and 367 of the 1947 BAKER (or Composite) CATALOG. Technically minded operators should read Baker Broadcast No. 21, which contains details of field applications and engineering details on this important equipment. Any "Baker Man" or Baker office will be glad to deliver *your* copy.

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THESE FACTS ARE INTERESTING

Note in Figure 3, below, how casing hanging vertically in a slightly off-vertical hole, results in a dangerous condition for successful cementing. Contact points at A and X prevent proper encasement of the pipe with cement slurry. The illustration next at right shows how a Baker Casing Centralizer near the shoe, and another one up the hole, provide the desired uniform annulus to permit placement of the predetermined thickness of cement all through the critical area.

Figure 4 shows casing extending through an intermediate oil zone that is to be protected by cement both below and above the productive sand. Although the hole is deflected only slightly from vertical, danger points exist at X and Y because a uniform sheath of cement around the casing cannot be secured. How Baker Casing Centralizers overcome this condition is shown in the view at right, Figure 4.

Figure 5 shows how Baker Casing Centralizers provide properly centered casing on a C.P. job, and insure the effectiveness of a Baker Metal Petal Basket by allowing its spring-backed petals to contact the formation evenly.

Figure 6 shows how Baker Casing Centralizers are used to center the casing at critical cementing points and provide the best possible conditions for successful squeeze jobs and other remedial work with Baker Cement Retainers. The interesting details of this job are included in the Baker Casing Centralizer Broadcast which will be sent promptly upon your request.

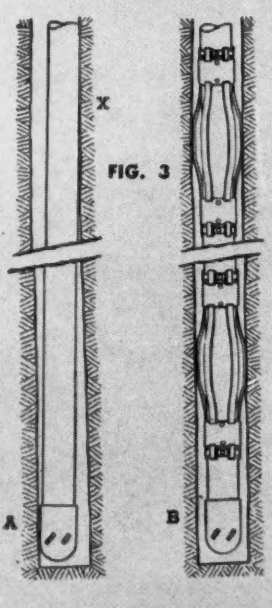


FIG. 3

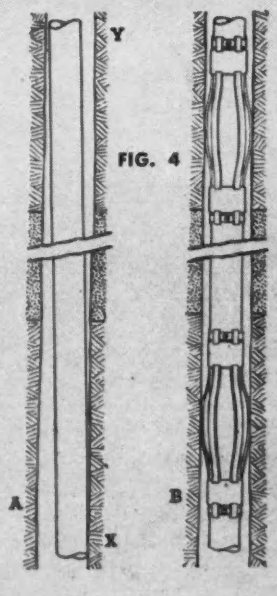


FIG. 4

FIG. 5

FIG. 6

More Middle East Crude Moving Toward U.S.

Standard Oil Company (N.J.) and Socony-Vacuum Oil Company are beginning a program of stepped-up shipments of Middle East crude to the U. S. Each originally aimed at a 15,000-barrel a day delivery average, and Chester Smith, Jersey Standard vice president, says his company will hit that stride by May. Socony-Vacuum by that time expects to reach an average of 17,000 barrels a day and gradually increase it after January 1, 1949, to 40,000 barrels a day, augmenting its current purchases of Saudi Arabian crude with oil from Iran and Kuwait.

Both companies now have five T-2 tankers en route from the Persian Gulf to the U. S. East Coast. Jersey Standard has at sea three 138,000 barrel ships recently acquired from the Maritime Commission. In addition that company has an order for eight new "super-tankers" of 238,000-barrel capacity each. The first of these ships is scheduled for delivery late in December and is expected to go into Caribbean service prior to making the Middle East run.

Jersey Standard's three and Socony-Vacuum's two tankers are due on the East Coast between April 10 and April 15 to unload a total of 640,000 barrels of crude. Standard's tenders will go to Esso Standard Oil Company refineries at Bayway, Baltimore and Bayonne. The Socony-Vacuum cargo will be processed at the company's Paulsboro plant.

Standard's crude is being lifted in accordance with the company's participating arrangement with Arabian American Oil Company, and in addition a straight purchase deal has been completed with Anglo-Iranian Oil Company.

Socony has chartered 11 tankers of the T-2 type to transport its oil. In addition the company has arranged to have built seven new tankers, each of 26,500 tons deadweight. Three of the new ones are scheduled to be ready for use in 1949. The one-way trip for tankers from the Persian Gulf to the U. S. east coast takes about 30 days, including loading and discharge time.

The government plans to lift restrictions on maritime sales limiting tankers so disposed to domestic runs. This would permit needed ships to enter the Persian Gulf run, and it is known that several companies are ready to put augmented fleets into Middle East service as soon as they can do so.

Jersey Standard is preparing for heavy tanker movements from Ras Tanura, loading points for its Aramco-purchased crude. The company's participating arrangement in Middle East Pipe Lines, Inc., is contingent on the completion of the pipe line and until consummation of the participation deal, Jersey will make outright purchases of Iranian oil. The company's proposed participation in Aramco has no such qualification, and hence crude from that source can be acquired on the joint account.

To maintain a combined average of 30,000 barrels a day, deliveries of Middle East crude will require, on the basis of a 32-day run, about 15 tankers of T-2 capacity in steady service.

Socony-Vacuum, which has been bringing Middle East crude to its Paulsboro refinery since July, 1947, largely for experimental purposes, but now plans to process the increased shipments in that plant in order to release a certain amount of Texas crude for handling by its Midwestern refineries to make gasolines and heating fuels.

Commercial Production Indicated in Turkey

The Turkish government has reported a well on the Ramandag structure in the southeastern part of the country for what may be Turkey's first commercial production. Not finally completed, the well swabbed heavy, 15-gravity oil at the rate of 300 to 400 barrels daily during a test. Total depth is 4348 feet. Drilling has shown approximately 125 feet of pay in an Eocene limestone, the formation from which this well is being tested.

Seven wells have been drilled on the Ramandag structure. Showings were reported in wells drilled during 1946, but the current test is the first which seems likely to produce in any quantity. One of the previous wells pumped a small amount of heavy oil.

The development of the oil industry in Turkey is under the direction of the Maden Tetkik ve Arama Enstitusu (Mining, Research and Exploration Institute) of which Ihsan Ruhi Berent is president. Berent went to the U. S. in July, 1947, and purchased enough drilling equipment to get the current program under way. Also during 1947 a contract was signed with Drilling and Exploration Company to supervise actual drilling work on a contract basis, drilling the locations selected by the technical staff of MTA. At the same time geophysical crews of United Geophysical Company is conducting seismic surveys for the Institute.

The Turkish government is adopting a program of development of the resources of the nation, but is reluctant to grant concessions to foreign operators. A number of companies have applied for concessions, but the government has refused to consider them, preferring to operate its industry as a nationalized project.

Also in line for development is the Adana structure, in the south central part of Turkey, and very near the Mediterranean coast. No actual drilling for oil has been done at Adana, although as far back as 1937 core holes were started, ranging from about 300 to 1000 feet in depth, and the structure has been outlined in part. About 20 of these test holes have been drilled, and showings of oil have been found in many. Geophysical work was started during the past year in the area, and it is expected that deep-well drilling will begin there before very long.

Intensified Drilling Brings Hike In Poland's Output

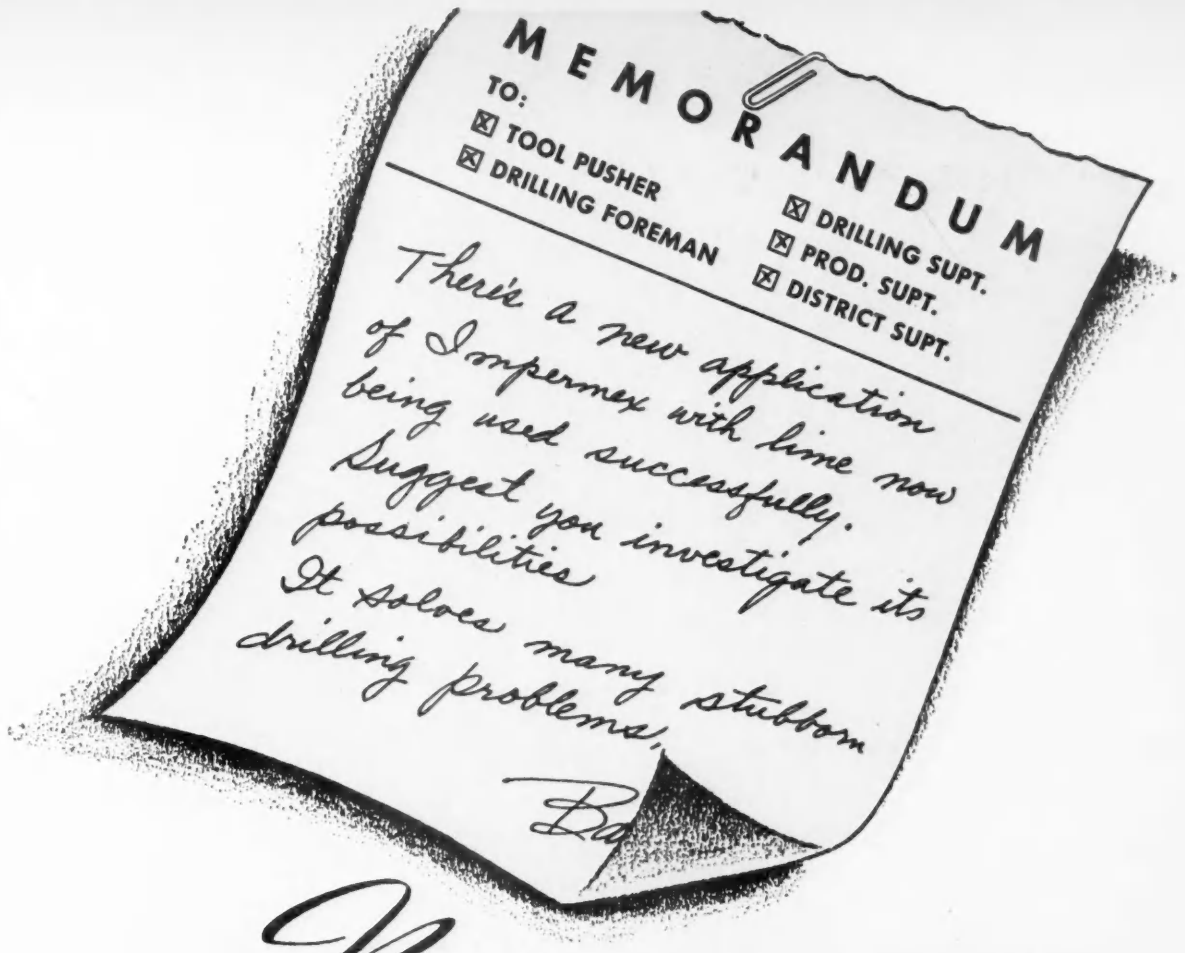
Poland produced 83,005 barrels of crude during December to bring the yearly total to 951,398 barrels, or nearly 10 percent more than the 1946 output. Increases in production were made possible by increased drilling, with more than 50 percent more footage represented in the 156,600 feet of hole drilled during 1947.

Much of the drilling was in exploratory wells, principally in an effort to develop the substantial gas reserves. More than 5 billion cubic feet of gas were produced and marketed in 1947.

Oil Companies Sue for War Damage Done in Burma

A suit has been instituted in the Burma Higher Court by Steel Brothers, managing agents for Attock Oil Company and Indo-Burma Petroleum Company, according to reports in England. The suit is for recovery of about $720,000 in war damages.

This is thought to be the first step in what may be protracted legal battle to determine whether the Burma or British governments are liable for damages done to the property of oil companies and others during the "scorched earth" campaign before the Japanese invasion in 1942.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3. **Low water loss, less than 2 cc. A. P. I.**
4. **Thin filter cake, on the order of 1/32".**
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6. **No interference with electrical logs.**
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Operators using this IMPERMEX-lime mud also find that it will take a lot of rough treatment while requiring little critical maintenance. And it offers no difficult mixing problem.

This IMPERMEX-lime mud differs from conventional IMPERMEX muds which also may use lime. In the new application, operators first prepare a saturated lime-water solution. Next they use this solution as the mixing water for the clay and IMPERMEX.

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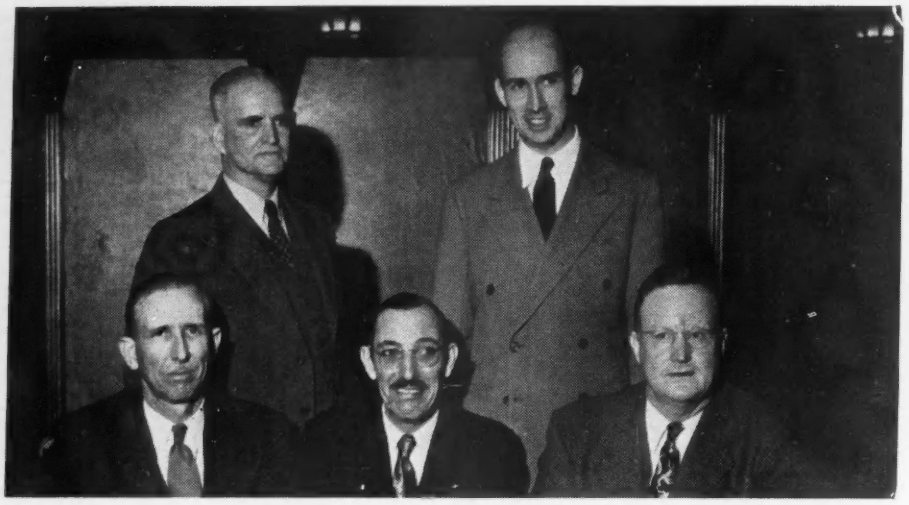


FOREIGN VISITORS at the March 8 meeting of the Houston Chapter of Nomads were, front row, left to right, H. C. Smith, Shell Oil Company, Colombia; John T. Gay, Aramco, Saudi Arabia; E. E. McGar, Shell Oil Company, Ecuador. Back row, D. C. Livingston, International Petroleum Company, Ecuador; J. R. Coleman, Arctic Contractors, Fairbanks, Alaska.

Houston Nomads Pay Tribute To Old-Timers of Tampico

The "Old-timers of Tampico" were guests of honor at the March meeting of the Houston chapter of Nomads. It was quite fitting that export equipment men should pay tribute to some of the pioneers of foreign exploration and development, and despite the changes that have taken place in methods and conditions since the old days of Tampico, the Nomads and the "Tampiquenos" have much in common.

The evening was a pronounced success with 42 Tampiquenos present, and a total attendance of more than 125, including guests from countries outside the U. S.

The entire program was devoted to the Tampico old-timers. J. W. Bradbury of Gulf Oil Corporation, the master of ceremonies, called on the Tampiquenos to introduce themselves and give a brief account of the time spent in Mexico. Some of the visitors had served in Mexico as far back as 1907, a number having spent 20 years or more in that area, and reminiscences of problems of living conditions, moving equipment and drilling wells were eye-openers to some of the newer members of the oil fraternity.

It was proposed by Jim Bradbury, and unanimously acclaimed, that a permanent organization of Tampiquenos be formed. Harry S. Kaplan, Gulf Oil Corporation, Houston, was named chairman of an organizing committee.

The following Tampiquenos were present: R. L. Agee, W. A. Baker, Ben C. Belt, Allen P. Berry, O. L. Brace, J. W. Bradbury, M. E. Brock, S. G. Castle, L. G. Chapman, C. H. Chase, Christy Clarke, Shaw Cranfield, E. M. Crawford, J. E. Douglas, R. F. Gousoulin, Frank Harrison, H. J. Hedges, W. F. Henniger, M. A. Jacobson, Harry S. Kaplan, C. H. Lane, Alfred L. Lott, Clyde McDonald, A. J. Mendive, H. E. Minor, E. J. Nicklos, Homer A. Noble, Walt Osterhoudt, L. W. Pearce, H. Raab, G. J. Raymond, Parker A. Robertson, L. D. Snow, G. W. Strake, Ray J. Thompson, Boyd Tillman, John Vetter, Paul Weaver, J. F. West, C. R. Whitehill, J. R. Winston, and W. H. Woods.

Dr. Gustav Egloff, of Universal Oil Products Company, Chicago, will be guest speaker at the April 7 meeting of Houston Nomads.

Former Tampiquenos Plan Houston Party May 5

A dinner party for all people who have worked in Tampico, Mexico, is being planned for May 5 (the Mexican national holiday) in Houston. A large number of oil men who formerly worked in Tampico were honored recently by the Houston Chapter of the Nomads Club. While many of those who will attend the party will be oil men, it is open to all former Tampiquenos.

Those desiring further information or wishing to attend should contact H. S. Kaplan, Gulf Oil Corporation, Houston.

Search for Oil in Italy Receives New Impetus

The search for oil in Italy apparently has been accelerated as a result of agreements between the Azienda Generale Italiana Petroli (AGIP) and the Anglo-Iranian Oil Company and Standard Oil Company (N. J.).

It now appears that there is a possibility the Po Valley may hold more prospects for oil production than the Appenines where most of the previous exploration had been concentrated. The discovery of an important gas accumulation at Caviaga (Lodi) at 4500 feet, and results of drilling there to date would encourage deeper drilling. The first four wells at Caviaga are producing about 5,300,000 cubic feet of gas daily at pressures approaching 2100 pounds. A well now drilling is scheduled to 9000 feet in the hope of finding oil below the gas horizon. Gas outlet is to be provided by lines between Caviaga, Milan and Bergamo.

Geophysical work in the San Giorgio Piacentino district between Pontenure and Busseto has indicated structures as deep as the Lower Oligocene, and although a little oil is being found in shallow horizons, it is now intended to drill to 9000 feet in the hope of finding possible Oligocene oil.

Seismograph geophysical equipment as well as heavy drilling rigs are being acquired by AGIP from the U. S. and a program of intensified exploration of the Po Valley is to get under way this year.

In the zone between Ferrara and Bologna, where Western Geophysical Company has recently done some survey work, core drilling is in progress which may result in defining some structures for deeper exploration.

Italy is reported to have concluded a trade agreement with Roumania which provides for the supply of about 4 million barrels of petroleum products in settlement of Italian investments in Roumania, and it is also reported that discussions are under way with Albania and the USSR with a view to obtaining crude oil in exchange for manufactured articles.

Danish American Prospecting Company, a subsidiary of Gulf Oil Corporation, is moving its rig to a new location in Denmark after having abandoned the first deep test drilled in that country.

Vinding 1, in West Central Jutland, southeast of Holstebro, was abandoned due to having stuck drill stem at total depth of 7985 feet. This well was spudded in July, 1947, and was definitely abandoned late in December. The new location, Gassum 1, will be in East Central Jutland, 28 miles north of the town of Aarhus and about 55 miles northeasterly from Vinding 1.

In addition to geophysical work carried out in the country the company has maintained a structure drilling rig in Denmark throughout the year, and has confirmed by core drilling the locations of several shallow salt domes indicated by geophysical work.

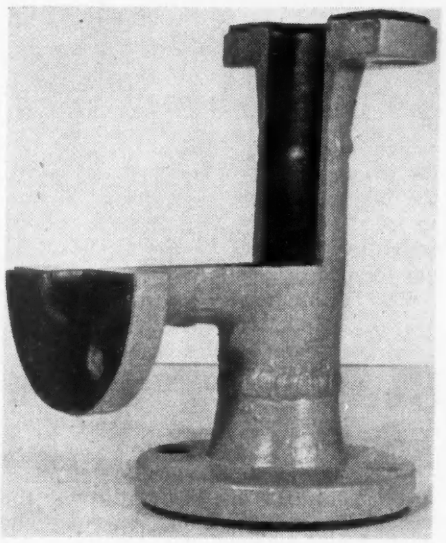
Czech-Polish Deal

Czechoslovakia reportedly has made agreements with Poland under which the former country will extend its long-distance pipe line system to Tesin where it will obtain natural gas for its industries at Vitkovice and Trinec. In return for the gas Poland is to reecive motor vehicles and drilling equipment.

NEW EQUIPMENT and Literature

1—Plastic Lined Pipe

Combining the highly resistant properties of Vinyl resins with the strength and flexibility of steel are plastic lined pipe and fittings. Vinyl resins are compounded with proper chemically resistant



pigments and plasticizers, and then are extruded in the form of a tube which has a wall thickness of 50 to 60 thousandths of an inch. The diameter is such that these extruded linings can be placed easily in the interior of standard steel pipe. The plastic tubing is tested prior to insertion in pipe and is coated with an adhesive. Heat and pressure are applied and the plastic makes an intimate bond with the steel.

To provide adequate protection against chemical attack at the flanges the pipe line is molded around the edge of the flange. A different formulation of the resins of the same type is required to meet the requirements of a flange facing and gasketing material. This is molded against the flange face at the same time the pipe liner is molded around the edge of the flange. These two materials are then bonded together so that when two flanges are placed face to face, the pipe liner material of one face is in contact with that of the other.

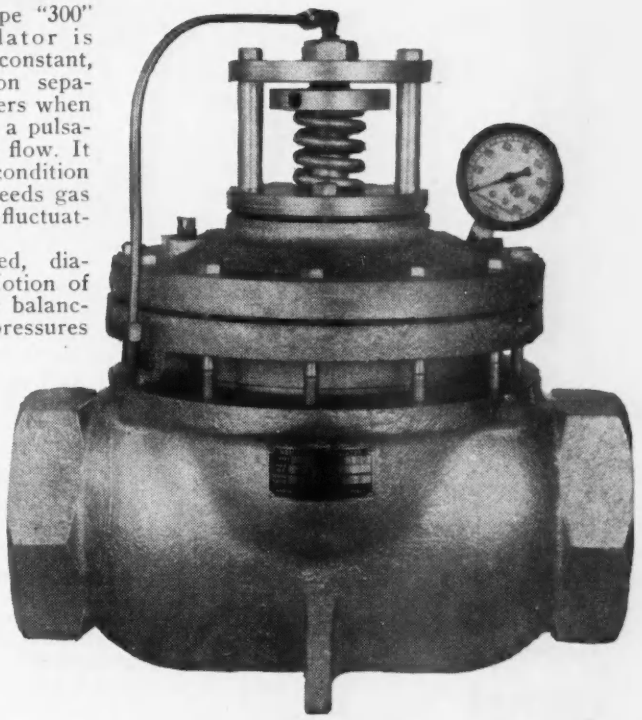
For additional information write Amercoat Division, American Pipe and Construction Company, P. O. Box 3428, Terminal Annex, Los Angeles 54.

2—Tool Joint Compound

Offered as positive protection against drill collar washouts is a new product, DRA-LED Joint Compound. Composed of 90 percent metallic lead, Dra-Led is anti-galling and is recommended for maximum efficiency. It is available in quart cans (12½ pounds) or in gallon can (50 pounds).

For additional information, write C. H. Dragert Company, Dallas.

3—Back-Pressure Regulator



The Merla-Parks Type "300" back pressure regulator is adapted to maintain a constant, steady back pressure on separators or emulsion treaters when such equipment handles a pulsation or heading type of flow. It also may be used for a condition where such equipment feeds gas to a gathering system of fluctuating pressures.

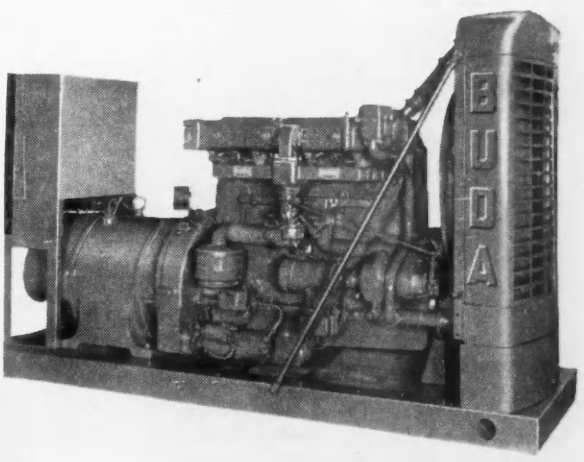
It is a pilot-operated, diaphragm motor vavle. Motion of the stem is obtained by balancing or unbalancing the pressures on opposite sides of the diaphragm, the degree of unbalance being controlled by the pilot mechanism. There is no unbalance caused by the large cross-sectional area of the main valve. This is compensated for in the pilot action.

There is no spring to hold the valve open or closed, eliminating any factor which would prevent the valve from giving straight line regulation of pressure from a fully opened to a fully closed position.

The main valve stem, working through an O-ring packing, is lubricated from an oil reservoir, which is sealed and has a capacity of one pint lubricant. The valve is installed in the line requiring no connection to the line for control pressure. The controlled pressure is indicated by a pressure gauge mounted on top of the valve.

For additional information write Merla Tool Corporation, P. O. Box 2576, Dallas 1.

4—Electric Generator Sets



Illustrated is one of the 23 sizes and models of a new line of industrial gasoline engine electric generator sets which are available in direct current or alternating current output, single or three phase. Power output ranges from ten to 125 kilowatts. Each set is complete and fully equipped with controls, generator, radiator, and engine mounted on a self-contained base.

Gasoline engines (also available with natural gas and butane engines) are water cooled and compactly built. Full circulating pressure system of lubrication is provided to all crankshaft bearings, camshaft bearings, rocker arm bearings, and rocker arm shaft. Equipment on engines includes electric starter, lubricating filter, and air cleaner.

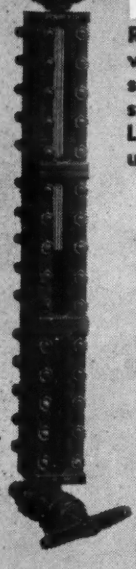
The generator is direct-connected, single ball bearing, heavy-duty type, drip-proof construction, and conforms to AIEE and ASME standards. Control panel is complete with voltmeter, ammeter, circuit breaker, rheostat, and engine controls.

For additional information write The Buda Company, Harvey, Ill.

PENBERTHY
Liquid Level GAGES

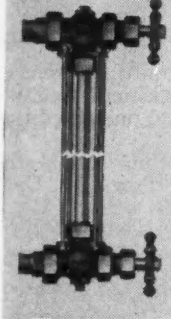
REFLEX

Reflex type complete with gage valves. Liquid shows black—empty space shows white. Liquid level is always unmistakable.



TRANSPARENT

Transparent type complete with gage valves. Used where through vision is desired under high pressures and/or temperatures.

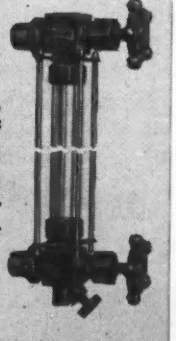


DROP FORGED STEEL

Tubular glass type, Chrome-Moly temperature resisting steel body, stainless steel trim, regrinding removable seats.

ALL IRON

Tubular glass type, extra heavy body of special high strength alloy iron, shanks alloy steel, trim stainless steel, valves self-cleaning.



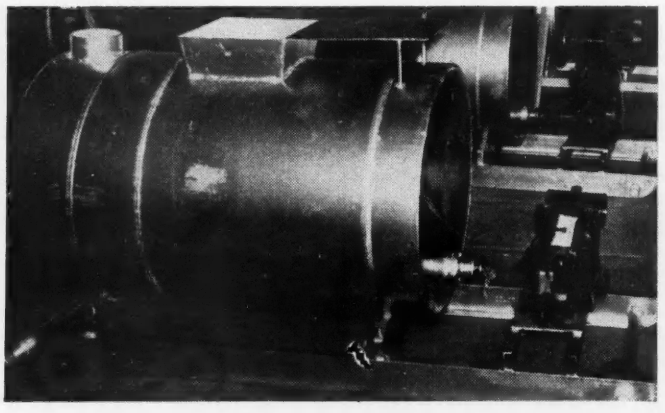
There is a Penberthy Gage of superior quality for every liquid level gage requirement. Gages are fabricated to customer's specifications from special alloys to meet unusual corrosive and temperature conditions. All Penberthy Gages conform with API-ASME requirements.

3277-B

PENBERTHY INJECTOR CO.
Detroit 2, Mich.
Canadian Plant—Windsor, Ontario

NEW EQUIPMENT LITERATURE

5—Mud Mixer



A portable mud mixing unit provides fast and efficient mixing of drilling muds and chemicals. The unit connects directly into the suction of the mud pumps with a four-inch valve to regulate the flow into this line or into the mud stream as desired.

In operation, the mixer is half filled with dry mud which is mixed to the desired viscosity or weight before turning the drilling fluid into the pump suction or mud stream. Its operation does not affect pump pressure or rig shutdown time.

The mud mixer consists of a fabricated steel tank of 450-gallon capacity inside of which is an eight-inch outboard motor boat propeller powered by an air-cooled gasoline engine or electric motor. A system of baffles inside the tank directs the circulation during the mixing process. The mixer is said to mix approximately ten sacks of weighting material or one sack of jel per minute.

For additional information write Wichita Mud Mixer Company, P. O. Box 64, Wichita Falls, Texas.

6—Dead Line Anchor

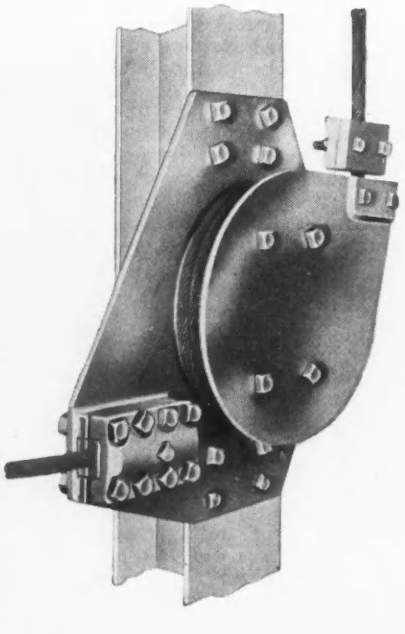
Two models of drum-type dead line anchors offer new construction characteristics to conserve and protect drilling lines. One model is available for attachment to the corner column of the substructure and the other for anchoring to the derrick corner pier. Both models are similar in construction and operation. They are welded from steel plate which holds weight to a minimum and insures ample strength at all stress points.

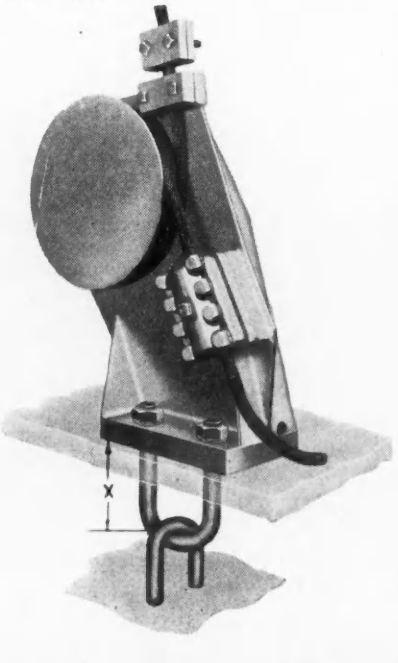
The drum-type dead line anchor offers a safer and more practical method of securing the dead end of the drilling line. No cable clips are used and no sharp bends are allowed which would have a tendency to damage the line.

To anchor the dead line, three turns are taken around the large diameter drum before the line passes through the bronze-lined form-fitting clamp. The drum functions much the same as a cathead.

A slack clamp is placed on the working side of the line which prevents uncoiling of the line on the drum when slack is thrown into the dead line. By removing the slack clamp and lossening the bronze-lined clamp, a new section of line may be pulled from the storage spool through the blocks without removing the line from the drum.

For additional information write International Derrick & Equipment Company, Ideco Building, 1315 Pacific Avenue, Dallas.





FORM-SET

Even when Form-Set rope has been cut, the wires and strands cannot fly apart. There are no locked-up inner forces to make the rope "wild."

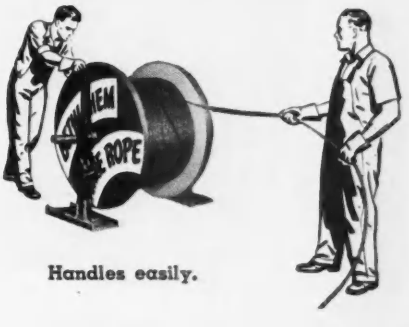
plays on your side

What we mean is, Form-Set rope begins to save you time the instant you unreel it. Even as the first few feet come off the reel, Form-Set starts to cooperate. You'll notice how it resists kinking; how smoothly and easily this flexible wire rope flows around drums and sheaves. Doesn't waste working time by fighting every move you make.

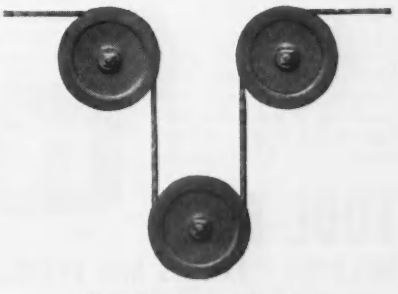
The reason is that Bethlehem Form-Set is preformed rope, and the preforming process relieves internal stresses. The steel wires and strands are "relaxed" at the plant by mechanical means, and the tension can never return. This rope, therefore, is always tractable, well-behaved, easy to handle.

There's another big advantage, too. Because of its freedom from internal stress, Form-Set rope better resists bending fatigue. Thus, on applications requiring sharp or reverse bends, Form-Set often has longer life.

There are probably certain sizes and types of Bethlehem rope that are favorites of yours. Any or all of them can be obtained with the Form-Set feature. A Bethlehem man will be glad to point out where Form-Set rope will be of greatest advantage to you.



Handles easily.



Ideal for reverse bends.

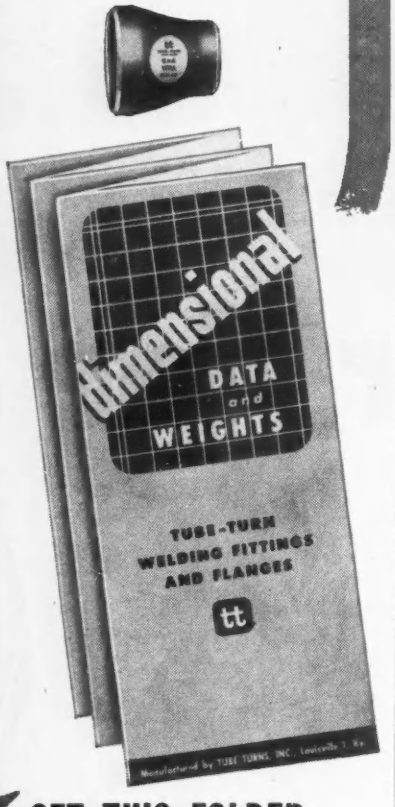
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

When you think WIRE ROPE . . . think BETHLEHEM

HOW BIG?

is a Welding Fitting



GET THIS FOLDER

Dimensional Data and Weights of Welding Fittings and Flanges: This folder opens up to man-size tables giving you dimensional information concerning Tube-Turn welding fittings from ½" to 30" in standard weight and extra strong, and flanges in all sizes and weights. It's a really useful reference tool. Keep a copy handy. Mail coupon.

TUBE-TURN

TUBE-TURN—*T. M. Reg. U. S. Pat. Off.*

WELDING FITTINGS AND FLANGES

District Offices at New York, Philadelphia, Pittsburgh, Detroit, Chicago, Houston, Tulsa, San Francisco, Los Angeles

Tube Turns, Inc., Dept. 3909, Louisville 1, Kentucky

Please send "Dimensional Data" folder.

Name.....

Position.....

Firm Name.....

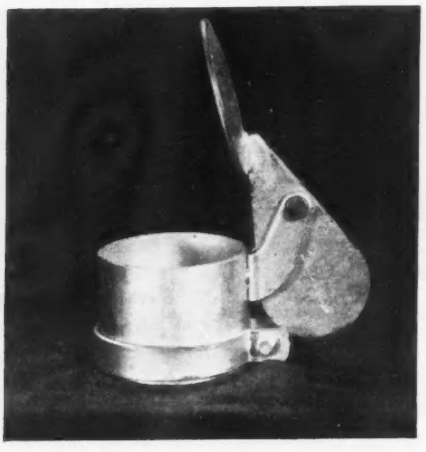
Street.....

City.....*Zone*....*State*.....

NEW EQUIPMENT LITERATURE

7—Exhaust Pipe Cover

Protection against dirt, rain and insects which gain entrance into the open end of exhaust pipes during storage or idle periods can now be afforded simply by a new Weathercap exhaust pipe



cover. The pipe cover consists of a counterbalanced circular cap slightly larger in diameter than the outside diameter of the exhaust pipe and is supported by a bracket attached to an exhaust pipe extension piece which is fastened to the end of the exhaust pipe by a circular clamp.

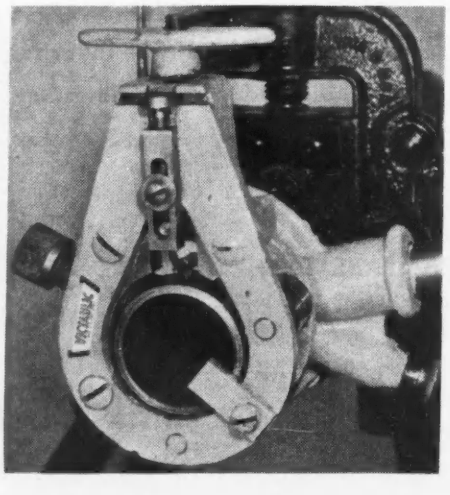
The cap is perfectly balanced and will open immediately upon starting the engine. The engine exhaust pressure keeps the cap open while the engine is running, and as soon as the engine is stopped, the cap automatically closes, thus preventing water, dust or any other foreign matter from entering the exhaust manifold.

For additional information write C. R. Taylor & Company, Garden City, Kansas.

8—Portable Pipe Groover

A portable automatic pipe groover has been designed to convert plain end pipe so it may be used with Victaulic Couplings and fittings.

The device, known as the "Vic-Groover," may be operated by hand or power, and it is said to groove pipe in half the time and effort required for threading pipe. Cutting perfect grooves to the proper depth automatically, the "Vic-Groover" is light in weight and is easily carried to isolated locations for field grooving.

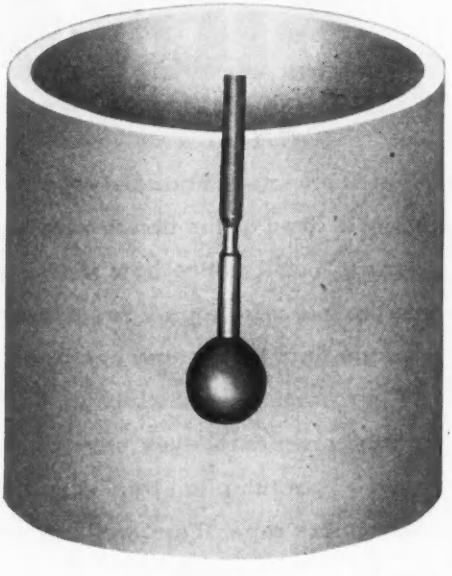


The "Vic-Groover" is available in sizes to accommodate pipe sizes of from ¾-inch to four-inch.

For additional information write Victaulic Company of America, 30 Rockefeller Plaza, New York 20.

9—Pipe Line Anodes

A new method of welding has been developed that greatly simplifies the problem of permanently attaching anode leads to pipe lines. This method employs the thermit process which consists of the use of granular metals, principally aluminum and copper oxides, to produce molten metal and to direct this metal against the objects to be welded. Both the apparatus and the mechanics of operation have been very simply worked out so that any workman can procure welds



even more surely made than are obtained by gas or electric welding.

The welding medium consists of powdered metals put up in a paper cartridge, the right quantity for each weld. A combination graphite crucible mold serves to receive the powder and the anode lead in separate chambers. This crucible mold is set on the pipe at the location of the weld, the powdered metal is dumped into the crucible, and the anode lead is inserted in the mold chamber which also holds the lead in intimate contact with the pipe. A flint gun is used to throw a spark into the powdered metal and this spark is sufficient to cause the powdered metal to ignite and set off a reaction. This reaction produces the right amount of superheated copper-alloy metal which flows upon the anode lead and pipe, resulting in a complete molecular union between the two.

For additional information write The Electric Railway Improvement Company, 2070 East 61 Place, Cleveland 3.

YOU WILL FIND MORE OIL

with Independent Exploration crews

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average over 14 years

of Seismograph field

experience, gives you

greater value for

your exploration dollars.

Independent

EXPLORATION COMPANY

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ESPERSON BUILDING — HOUSTON, TEXAS

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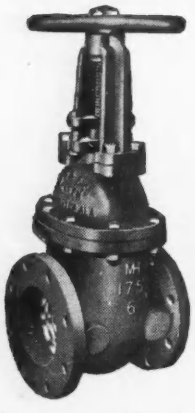
"Red Wheel"
VALVES, HYDRANTS
And Pipe Line Accessories



M & H valves are used in the oil industry for water, gas, steam, oil, chemicals and are furnished in all commercial sizes from 2" to 30", inclusive. They are cast iron body, bronze mounted, furnished double disc parallel seat or solid wedge. They are heavily proportioned and have a high factor of safety.

A. W. W. A.
HYDRANTS
Underwriters
Approved

Conform to American Water Works Association Specifications. Approved and listed by Underwriters' Laboratories and Associated Factory Mutuals. Well known and widely used for many years.

SPECIAL TRAFFIC MODEL is designed to yield at ground line under impact, repair being simply renewal of breakable bolts and breakable coupling on stem. High efficiency because barrel diameter not reduced and there are no working parts or obstructions in waterway.

OTHER M & H PRODUCTS

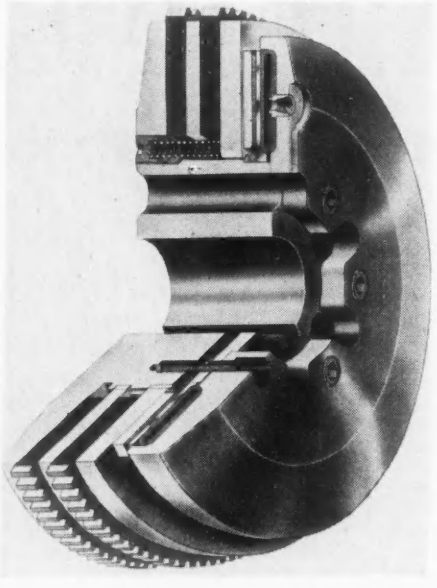
Fire Hydrants
Gate Valves
Tapping Valves
Special Castings
Tapping Sleeves
Check Valves
Floor Stands
Extension Stems
Mud Valves
Flap Valves
Sludge Shoes

M&H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA

NEW EQUIPMENT
LITERATURE

10—Friction Clutch

A new friction clutch for heavy duty applications is the Wichita Air-Tube Disc Clutch. It features direct axial pressure application by compressed air in a flat circular rubber and fabric air-



tube to engage the plates of a single or multiple plate disc clutch.

It requires no adjustments, has great torque capacity for a given diameter and length, and is unaffected by centrifugal force. There are no packing, diaphragms or gaskets. The tube is insulated from heat that might be generated at the friction surfaces and air cooling passages help keep the clutch cool.

It is available in 18-, 24- and 30-inch single and double plate sizes, having horsepower capacities from 40 to 1000. Other sizes will be available later.

For additional information write Wichita Falls Foundry and Machine Company, Wichita Falls, Texas.

11—Hand Tachometer

A new hand-held electric tachometer which weighs only three pounds is designed to give accurate and direct readings of linear speeds from ten to 10,000 feet per minute, and of rotational speeds from 100 to 10,000 revolutions per minute. Using accessories, rotational speeds from ten to 100,000 revolutions per minute may be measured.

The tachometer consists of two units: the head, which is placed in contact with the moving object, and the indicating unit to which the head is attached by a flexible electric cable. Speed ranges can be changed while the spindle is rotating because there is no gear transmission to shift for various speed ranges. Accurate speed indications are assured by a low driving torque of only ¼ ounce-inch. The instrument cannot be damaged by overspeeding.

Vibration from the rotating machine does not affect the reading or make the instrument difficult to read.

For additional information write Special Products Division, General Electric Company, Schenectady, N. Y.

12—Water Well Driller

The "Consol" well driller was designed to enable operators to drill their own wells at low cost. The driller is said to require attention only once every few hours during drilling to bail and readjust bit.

Dimensions of the base are six feet by six feet, and the unit is eight feet

high. Shipping weight is approximately 450 pounds. The frame is of channel and angle iron to provide rigidity. The drilling bit is of the same material used in oil well drilling bits. The dropping distance may be adjusted to meet the formation conditions. It operates at approximately 38 strokes per minute and is equipped with an automatic feed-out device which permits the cable to feed out freely as the drill progresses downward.

The drilling machine is powered by a ¾-horsepower electric motor or a 1½-horsepower gasoline engine. The unit is furnished complete with drill, bailer, and 100 feet of cable.

For additional information write Consolidated Industries, 9 South Colony Street, Wallingford, Conn.

★ EXCELLENT ★

AGE RESISTANCE

RESILIENT parts made from HYCAR American rubber resist the aging effects of air, sunlight, ozone, heat, cold, and all other types of oxidation. That's why they *stay* resilient—and stay on the job for a long, long time.

Other important properties of HYCAR American rubber are shown in the box at the right. And it's important to know that these properties may be had in an almost limitless number of combinations—each compounded to meet a given set of service conditions.

We make no finished products of HYCAR. But we urge you to ask your supplier for parts made from this versatile material. You'll learn for yourself that it's wise to use HYCAR—in difficult or routine applications—for long-time, dependable performance. For more information, please write Dept. HP-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

WHAT HYCAR DOES IN OIL FIELD APPLICATIONS

1. *Resists oil and gas—even under high pressures and temperatures.*
2. *Resists action of abrasive-laden fluid under high pressure and at high velocity.*
3. *Wears at slow rate even under worst conditions.*
4. *Makes a positive, leak-proof seal, even after a long period of service.*
5. *Provides high elasticity.*
6. *Gives high tensile strength.*
7. *Has minimum tendency to cold flow and compression set.*

Hycar

Reg. U.S. Pat. Off.

American Rubber

B. F. Goodrich Chemical Company

A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • KRISTON thermosetting resins • GOOD-RITE chemicals

13—Streamlined Casing Protector

This casing protector is streamlined to insure the best protection for both casing and drill pipe. The rubber lips that have proven so successful in the older style protectors are still incorporated in the smooth contour of this new style. The streamlined shape minimizes turbulent mud flow around the protector and permits a minimum change in the direction of mud flow. Formerly, abrupt changes in the direction of the mud around the casing protector produced a scouring action directly above and below the rubber and "ringing" of the drill pipe occurred.

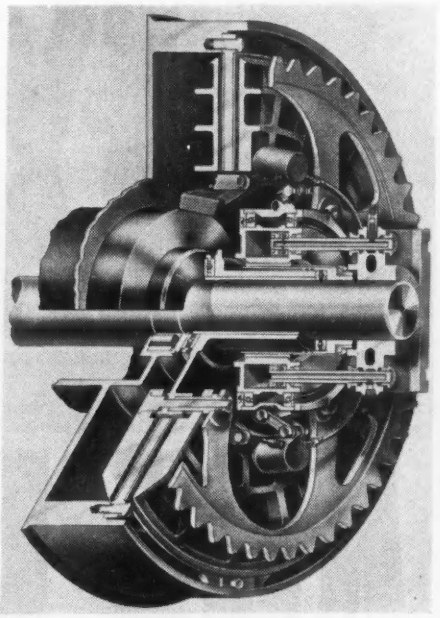
Streamlined casing protectors are manufactured from the same special PBX-D-25 rubber that has proven itself in deep drilling. They will keep their shape in any type of mud or brine and will always grip the pipe firmly. The long contact surface takes the wear instead of the casing or tool joint and the rugged lip construction gives gripping power at each end of the protector.

For additional information write Patterson-Ballagh Division Byron Jackson Company, 1900 East 65th, Los Angeles 1.

14—Full Air Clutch

A full air clutch has been designed to provide fingertip control and smooth, efficient operation. Designated as "Franksair," the clutch features over-center engagement and disengagement, light weight, high drum capacity, elimination of mechanical linkage, rotating air seals, and drilled shafts. Less heat is generated, the makers state, since the air-actuating mechanism is some distance from the area of clutch engagement, and single point hydraulically equalized adjustment insures full area engagement.

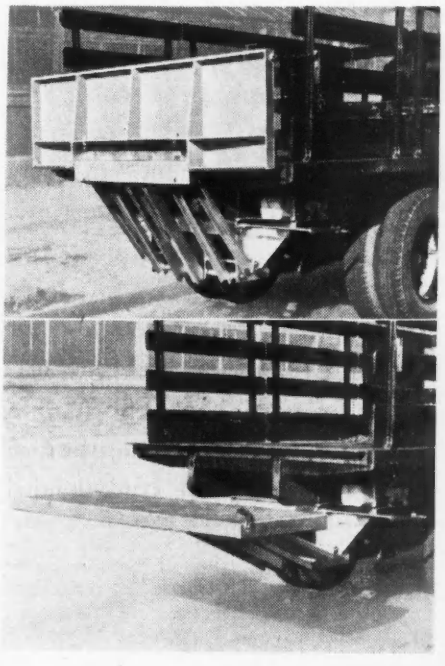
The Franksair clutch-actuator positively engages or disengages, by air pressure, a final-friction drive winch clutch on a cylinder and piston incorporated into the clutch assembly. It is a moveable annular cylinder on a fixed shaft which operates as a piston and valve arrangement actuated by air pressure introduced in either "in" or "out" chambers and engaging or disengaging the Franks double-faced center friction ring clutch.



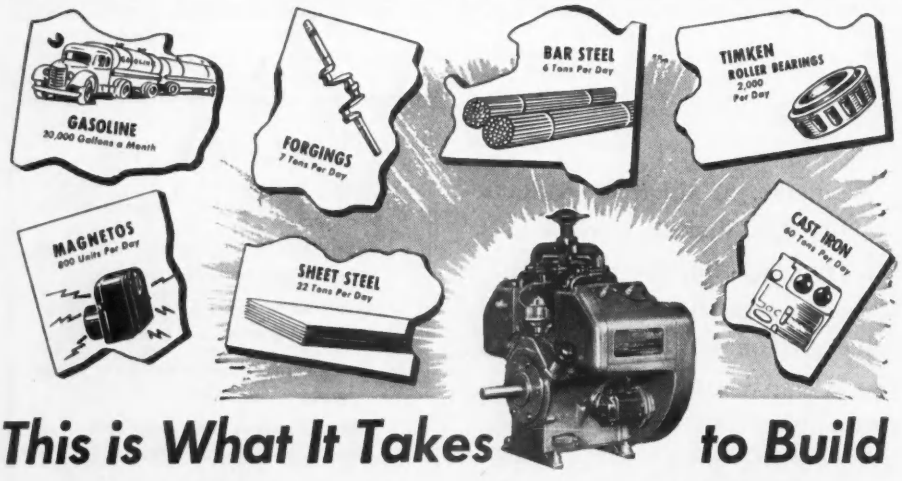
For additional information write Franks Manufacturing Corporation, Whittier Station, Box 3218, Tulsa.

15—Tail Gate Truck Loader

A handy, low-priced hydraulic tail gate loader for trucks has been introduced to speed up loading and unloading, and to minimize freight breakage. The lift platform operates over the full distance from ground to truck floor level, raising and lowering loads up to 1200 pounds. The platform remains level throughout its entire travel arc, and swings up to serve as a tail gate when the truck is on the road.



For further information, write The Day Company, 306 West 69th Street, Chicago 21.



This is What It Takes to Build

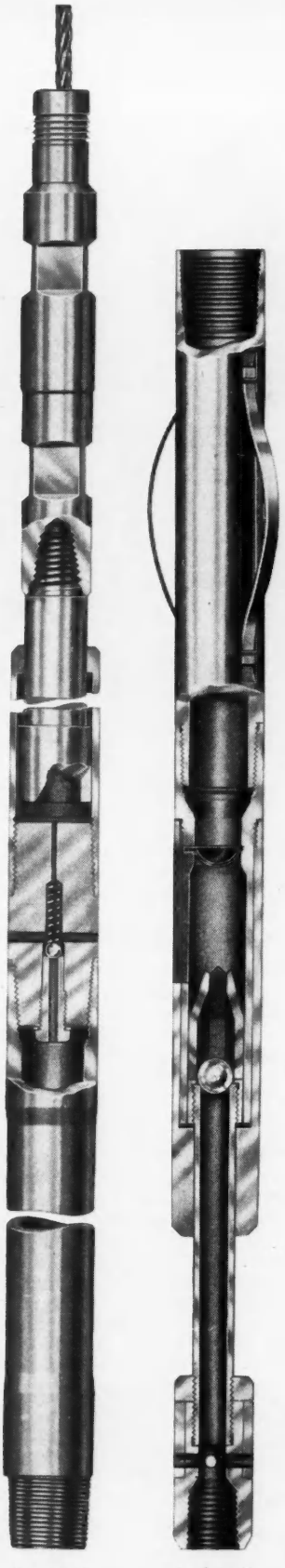
WISCONSIN *Air-Cooled* ENGINES

Trainloads of cast iron, bar steel, sheet steel and drop forgings; thousands of Timken roller bearings, magnetos, carburetors, fuel pumps and many other parts and materials . . . including 20,000 gallons of gasoline per month simply for factory test runs . . . that's what it takes to build Wisconsin Heavy-Duty Air-Cooled Engines!

But above all this *quantity* is the *quality* that is the final product . . . the Heavy-Duty Air-Cooled Wisconsin Engines that are serving Industry so dependably, in so many ways . . . as integral power units on a great variety of equipment, delivering "Most Hp. Hours" of on-the-job power service.

WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 Atlas Building, Tulsa, Oklahoma
M & M Building, Houston, Texas
Oil field distributors for Wisconsin Engines and all types of utility units.



Upper Half Grant Hydrostatic Bailer

Lower Half Grant Hydrostatic Bailer

Utilizing the differential between atmospheric pressure at the surface and hydrostatic pressure in the fluid column, the Grant Hydrostatic Bailer creates a powerful suction which cleans all removable materials out of the hole.

By its positive, surging action, the Grant Hydrostatic Bailer quickly breaks up the hardest sand bridges. Bridged-over tubing can easily be cleaned out without pulling tubing and killing a flowing well. Available in a full range of sizes. For complete information on the Grant Hydrostatic Bailer—recently improved to give even greater bailing efficiency—write or wire for Bulletin No. 11.

Proven GRANT Tools

Used Where Performance Counts

Hydrostatic Bailers	Bulletin No. 11
Liner Pullers	Bulletin No. 14
Pressure Releases	Bulletin No. 15
Casing Scrapers	Bulletin No. 17
Wall Scrapers	Bulletin No. 20
Bottom Hole Scrapers	Bulletin No. 21
Underreamers (Rotary)	Bulletin No. 24
Underreamers (Cable Tool)	Bulletin No. 27
"Forjaloy" Hole Enlargers	Bulletin No. 38
Reamers	Bulletin No. 43
Hydrostatic Perforation Cleaners	Bulletin No. 50
Dump Bailers	Bulletin No. 51
Roller Cutter Shale Bits	Bulletin No. 54
Sand Pumps	Bulletin No. 55
Impression Block Tool	Bulletin No. 56
Well Cleanout Equipment	Bulletin No. 57

Write for Descriptive Bulletins on these GRANT Tools

GRANT OIL TOOL COMPANY

Main Office and Plant: 2042 East Vernon, Los Angeles 11, California

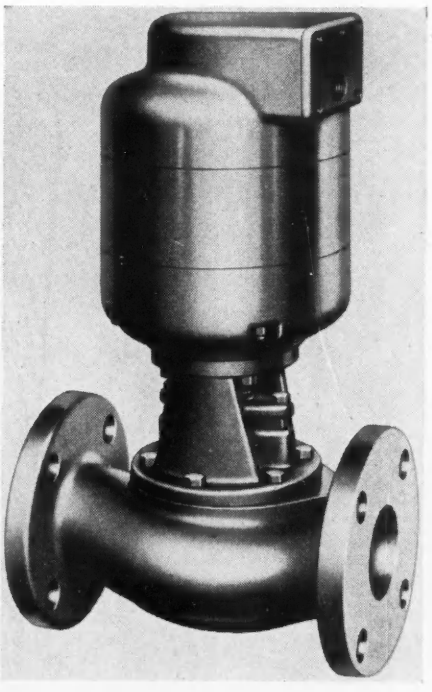
Branches at Bakersfield, Avenal and Ventura, California, and at Odessa and Houston, Texas

16—Circulator Pump

Model 1-B Rumaco pump is designed on centrifugal principles, and can be operated vertically, horizontally, or at any intermediate angle. The driving motor, direct-connected to the pump, is totally enclosed and equipped with grease packed, sealed precision ball bearings. No additional lubrication is necessary, therefore, all oilers and grease fittings have been eliminated. The motor is dynamically balanced by dynetric process to extremely close limits, insuring virbationless and quiet operation.

It is provided with opposing inlet and outlet for standard (125 pound pressure) two-inch pipe flanges. The unit can be installed easily in a pipe line of various sizes by use of pipe reducers. Designed primarily for circulation in hot water heating systems, this pump can be used for many circulating jobs.

This unit is available with ½-horsepower motor for other than ordinary water circulation where the fluids range between 200 and 600 standard Saybolt units viscosity at the operating temperatures.



For additional information write The Ruthman Machinery Company, 1809 Reading Road, Cincinnati 2.

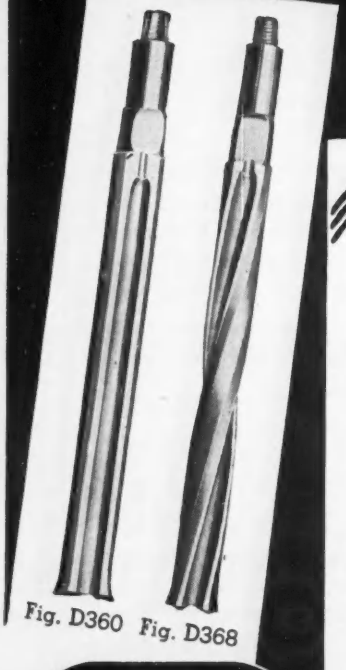
17—Spherical-Contact Bearing

The Halfco self-aligning, spherical-contact bearing consists only of a hardened, highly-polished, precision-ground steel ball around which a hard bronze or steel race is integrally formed. Full spherical-contact between the inner ball and the outer race allows extremely high loading. The three-inch bore bearing has an ultimate static load capacity in excess of 700,000 pounds. Another outstanding feature of this new bearing is its ability to accommodate up to 13 degrees of shaft misalignment.

Design of the Halfco bearing makes it well adapted to oil industry applications. Its high load capacity and self-aligning features make it ideal for the severe services encountered in oil well drilling and production. Used as rod end bearings on mechanical rod linkage controls, the Halfco bearing assures ease of operation and freedom from freezing of controls.

For additional information write Adel Precision Products Corporation, Burbank, Calif.

SPECIFY
SPANG
FOR THE BEST IN CABLE TOOLS



SPANG
HEAT-TREATED
DRILLING BITS

Spang Drilling Bits are forged by a patented process which assures a sound, homogeneous product. The steel is made to specifications, which have been developed out of a long experience, to give the maximum of footage per dressing.

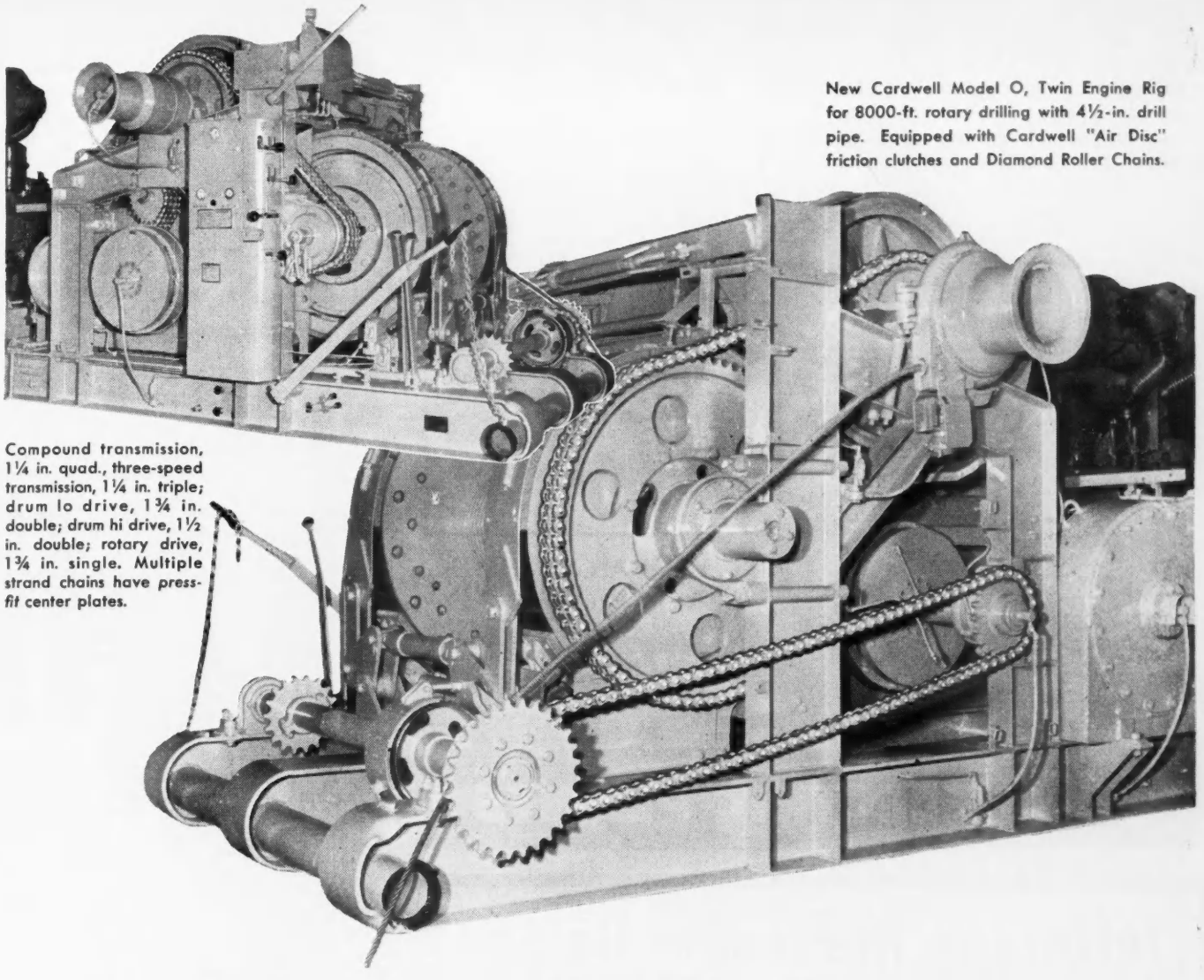
In the heating and forging operations, the most modern methods are used. Each step is carefully planned and executed to produce sound forgings. Heat treatment by use of modern furnaces with heat-recording instruments and experienced personnel insures the maximum of joint strength. A field dressing instruction chart is yours for the asking.

Spang Drilling Bits reflect the skill and knowledge that make every Spang Cable Tool a "Higher Standard" product.

THE HIGHER STANDARD

SPANG & CO.
BUTLER, PA.

YOUR DEALER SELLS SPANG TOOLS



New Cardwell Model O, Twin Engine Rig for 8000-ft. rotary drilling with 4½-in. drill pipe. Equipped with Cardwell "Air Disc" friction clutches and Diamond Roller Chains.

Compound transmission, 1¼ in. quad., three-speed transmission, 1¼ in. triple; drum lo drive, 1¾ in. double; drum hi drive, 1½ in. double; rotary drive, 1¾ in. single. Multiple strand chains have *press-fit* center plates.

On the Latest CARDWELL Draw Works

ALL DRIVES ARE DIAMOND

● With rig performance largely dependent on power drive performance, drive selection is of mutual and utmost importance to rig manufacturer and rig owner alike.

Operating in all parts of the world—often far from service, even in the U.S.A.—American-made rigs with Diamond Roller Chain Drives are universally recognized for their great reserve strength, long service life, enduring high efficiency, and reliability. Diamond Chains consistently help make more hole.

Matching field requirements and developments in oil country machinery since the days when marked improvements began shortly after World War I, Diamond Chain has more than kept abreast of the steadily increasing requirements for transmitting greater amounts of power at higher speeds.

Cardwell's many years of satisfactory experience with Diamond Roller Chains provide ample reason for their selecting Diamond for this latest completely chain-driven Model O Draw Works.

DIAMOND CHAIN COMPANY, Inc., Dept. 485 402 Kentucky Ave., Indianapolis 7, Indiana. *Tulsa Office:* 2238 Terwilleger Blvd.

DIAMOND ROLLER CHAINS

ONAN *Diesel*

ELECTRIC PLANTS FOR THE OIL FIELDS

Now there's an Onan Diesel Electric Plant to meet the requirements of any oil field application—to give long, full-capacity service under the severest operating conditions. Available in one-cylinder air-cooled, four and six-cylinder water-cooled models. For continuous heavy-duty operation, stationary or portable.

ONAN DIESEL ELECTRIC PLANTS—2,500 to 35,000 watts. ONAN GASOLINE-DRIVEN ELECTRIC PLANTS—350 to 35,000 watts. ONAN AIR-COOLED ENGINES—5½ and 10 hp (2-cyl.), 3¼ hp (1-cyl.).

D. W. ONAN & SONS INC.
4756 Royalston Ave., Minneapolis 5, Minn.

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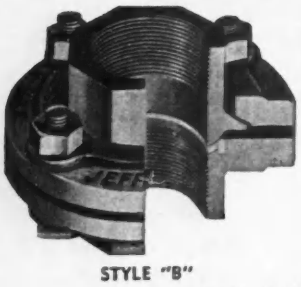
Onan PRODUCTS

ONAN ELECTRIC PLANTS

Jefferson Malleable Unions



STYLE "B"

JEFFERSON Style "B" three-piece flange union is made with brass-to-iron and iron-to-iron seats. Being made of highly refined AIR FURNACE iron, it assures you of lightweight construction, perfect ball joint, and positive seating arrangement, whether or not in alignment.

★ ★ ★

HYDRAULIC PRESSURE RATING

Sizes	Test Pres.	O. W. G.	S.W.P.-550 Deg.
½" thru 4"	2000#	800#	250#
5" and 6"	1200#	500#	250#
8" and 10"	1000#	400#	250#

Malleable iron used in all JEFFERSON unions meets ASTM-4733, Grade 35018—M. T. 53000 Lbs., giving 75%-more elongation 50%-more impact value and is 30%-stronger than cupola malleable iron.

Obtainable through your jobber

Jefferson Union Company, Inc.

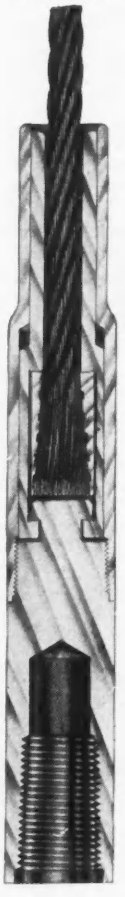
691 West 26th St.,
New York 1, New York

71 Gooding St.,
Lockport, New York

31 Fletcher St.,
Lexington, Mass.

NEW EQUIPMENT
LITERATURE

18—Rope Socket



The new type "Quick-Change" rope socket is simple in construction and consists of a body, a cap, two liners and a sturdy, tapered pocket thimble. The thimble is so designed as to fit all sizes of the new type sockets, and is permanently babbitted to the line in the conventional "fish hook" manner of securing rope ends.

In working assembly, the liners enclose the thimble and lock around the lifting neck of the body. Slanted shoulders on the exterior of the liners and the interior of the cap provide added retaining safety.

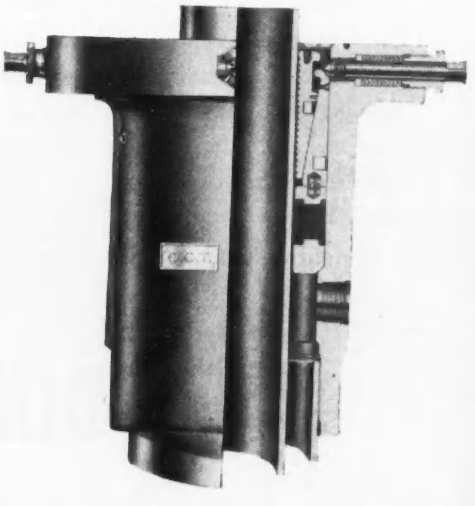
Breakdown tests performed by recognized standards laboratory resulted in a pull of 13,300 pounds to separate the sand line from the thimble. They are manufactured in a variety of standard sizes from 1¾-inch outside diameter to 2¾-inch outside diameter. Other sizes are available on request.

For additional information write Cavins Company, Long Beach, Calif.

19—Casinghead

A new line of wellheads has been designed to suspend and seal long, heavy strings of casing. According to the manufacturer, the new head, designated as O-C-T Type "C-19," employs the proven casing weight seal but with a new and simplified setting procedure.

Slips, packing element and bowl are a single split unit that is wrapped around casing, latched and dropped into the head with elevators holding desired tension on the casing. Upon reaching its seat in the casinghead body, suspension at the desired tension and a seal are



The LEADER...for 25 years!

MILLER SAND PUMPS

And Regular Bailers

- **Thousands of MILLERS in use Throughout the World!**
- **The Standard Clean-out Tool!**

O. D. Sizes on MILLER SAND PUMPS are: 2½, 3, 3½, 4¼, 5, 5½ and 7 inches. Lengths are 20, 25 and 30 feet. The bail is welded to heavy seamless steel tube. Long heavy grooved plunger assures a liquid seal. Has three interchangeable bottoms. Wire line is direct connected to plunger—gives greater suction. DOES THE JOB! FAST! ECONOMICAL!

MILLER REGULAR BAILERS are made in 2½, 3, 3½, 4¼, 5, 5½ and 7 inch O.D. sizes and in 20, 25 or 30 foot lengths. Sectional Bailers made to your specifications. See Composite Catalog, page 2666, for prices, parts and details.

MILLER SAND PUMP CO.

1524 SE 29th Street
BOX 4516, OKLAHOMA CITY, OKLAHOMA
Export Office
30 Rockefeller Plaza, New York 20, N. Y.

for all oilfield uses...

NEW BEDFORD ROPE

1. PROPER LAY
2. BEST MANILA AVAILABLE
3. EXTRA STRENGTH
4. RESISTANCE TO WEATHER
5. EASE OF HANDLING
6. SPECIAL TREATMENT

√Only the best manila available is used in NEW BEDFORD rope. Combed, blended, spun, formed, and laid, these strong, sinewy fibres make the rope tough and long-wearing. For all oilfield uses – cat lines, torpedo lines, spinning lines, cable tool lines—NEW BEDFORD turns in a top-flight performance.

Use of the best manila available is only one of six good reasons why NEW BEDFORD CORDAGE is better for every use. All six are found in all NEW BEDFORD ropes.

FREE! Write today for handy booklet on knots, rope splicing and whipping.

NEW BEDFORD CORDAGE CO.
233 BROADWAY, NEW YORK 7, N. Y.

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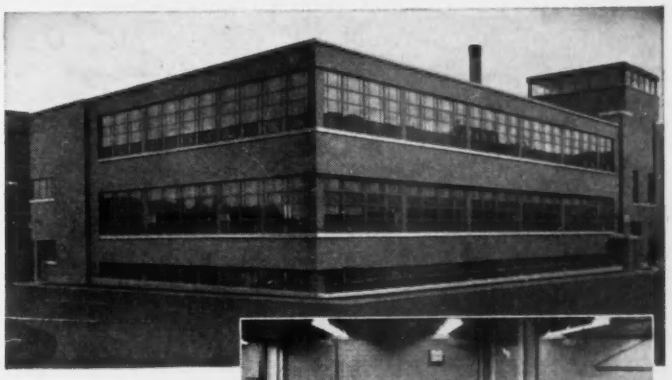
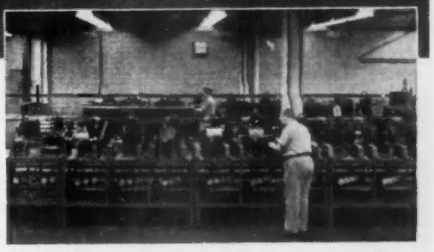




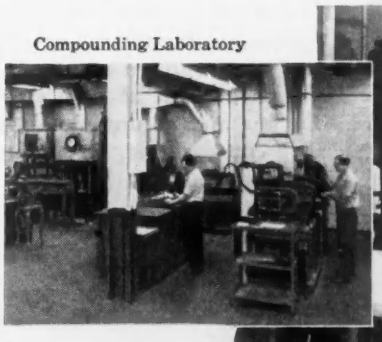
Testing Laboratories general view

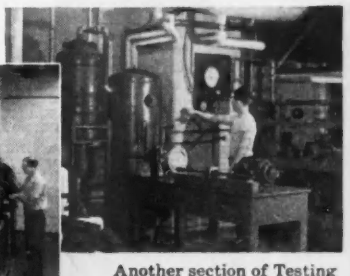
Research

Starting in 1887 with the fundamental question—"what makes packing pack?"—Garlock has extended its research from year to year until the newly constructed building shown above is now required to house Garlock's research activities. Garlock products are developed, improved and refined in these completely modern chemical, physical and rubber-compounding laboratories; thoroughly tested in the fully equipped test department and processed in the pilot plant before ever reaching the production department. This *Quality Control* is your assurance of uniformly high quality in every product sold under the Garlock name.

THE GARLOCK PACKING CO., PALMYRA, N.Y.
Tulsa, Okla. Houston, Tex. Los Angeles, Calif.

Compounding Laboratory





Another section of Testing Laboratories

Chemical Laboratory

GARLOCK

automatically effected as weight of the casing string applies sealing compression to the Hycar seal rings.

The hanger assembly may be lowered through blowout preventers, thus providing suspension and seal with the blowout preventers in place. The Hycar seal is under constant compression without displacement, and is confined on all sides by steel, protecting the seal rings against deterioration.

For additional information write Oil Center Tool Company, P. O. Box 3091, Houston.

20—Oil Industry Catalog

Allis-Chalmers equipment for the oil industry, built in a maximum range of types and sizes, is described in a 20-page bulletin. Products covered include Texrope power transmission equipment, drilling rigs, electric motors, motor controls, transformers, unit substations, generators, shale shakers, blowers, compressors, and centrifugal pumps.

Described and portrayed are the three types of power units for oil drilling rigs. These are Texrope-driven mechanical rigs, electric-mechanical, and direct-current full-electric rigs. Also featured is the company's new line of totally enclosed fan-cooled motors in sizes up to 2000-horsepower engineered to meet the particular needs of pipe line companies and oil refineries.

Published by Allis-Chalmers Manufacturing Company, Milwaukee 1.

21—Hydroplex Pump Bulletin

Bulletin 47-8020 describes the Hydroplex pump, a split case multi-stage centrifugal pump for low capacity and high-pressure pumping. The eight pages in two-colors cover various views of the pump, cross-section schematic, subassemblies, parts and dimensional drawings, and also installation photographs.

Published by Byron Jackson Company, Pump Division, Los Angeles 54.

22—Roller Bearing Data

The "DE" radial-thrust, self-contained, preadjusted roller bearings, are the subject of a 16-page illustrated book, No. 2196. The book contains tables of dimensions, weights, bearing capacities at given revolutions per minute, shaft fit tolerances, housing fit tolerances, and the necessary data for calculating the required bearing capacity for different types of machinery.

Published by Link-Belt Company, Ball & Roller Bearing Division, 519 North Holmes Avenue, Indianapolis 6.

23—Orifice Meter Computing Service

A four-page, two-color, illustrated bulletin describes an orifice meter chart integrating and computing service; a field and shop meter reconditioning and repair service; a new automatic bearing shaft lubricator; and the availability of several special gas measurement services.

Published by John P. Squier, Gas Measurement and Engineering Service, Dallas.

24—Pressure Control Equipment

Complete operating details, data and dimensions of all Otis sub-surface controls, equipment and special services are included in a 32-page, two-color catalog containing nearly 50 illustrations and drawings. Covered in the catalog are several new types of tools and equipment, including the Otis surface safety valve, two-zone pumps, pressure-lock packers, completion tools, and snubbing and control equipment featuring new-type pressure-operated control heads.

Published by Otis Pressure Control, Inc., 6600 Denton Drive, Dallas.

25—Rotary Table Bulletin

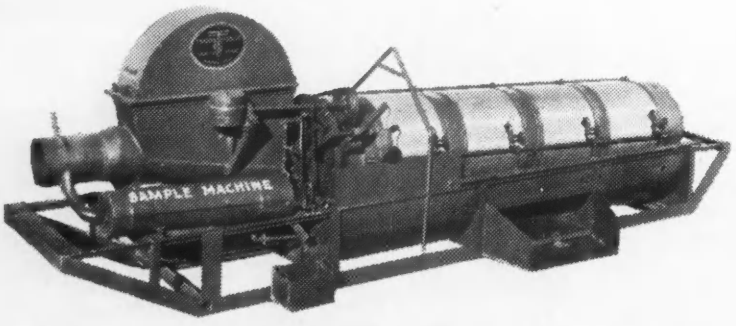
A 12-page, illustrated bulletin, No. 342, describes the Ideal MS-20½ rotary machine designed for medium-speed drilling and moderately deep holes. It includes specifications, line drawings, general descriptions of main parts, including spiral bevel gears, and lubrication.

Published by National Supply Company, P. O. Box 899A, Toledo.

"KILLER" SHALE SAYS:

I HAVEN'T CHEWED ON A MUD PUMP FOR WEEKS! THAT **THOMPSON SHALE SEPARATOR** IS STARVING US TO DEATH!

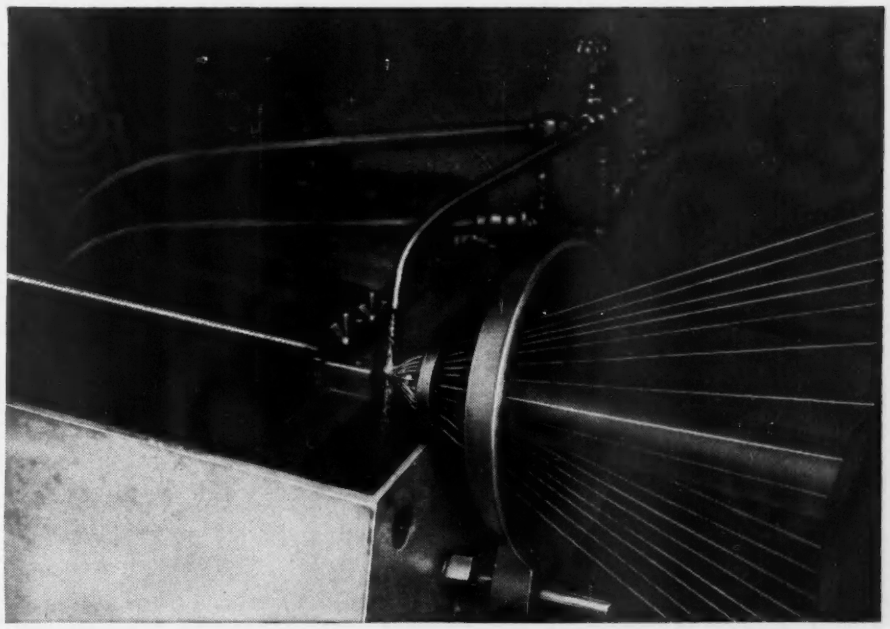
Damage from shale and abrasives can't eat into your profits when you condition drilling mud with a Thompson Shale Separator. Only clean mud goes back into the well to work without wear. No matter what volume of mud goes through your mud pump, there's a Thompson Separator to do the job. *Model "DWF" handles maximum flow from the biggest mud pumps now in operation.* Two other models for shallow and medium depth wells. Attached SAMPLE MACHINE provides instant and accurate foot-by-foot samples of cuttings. Easy to operate... invaluable to have.



Write Today for Free Illustrated Folder Containing Complete Data on all Thompson Separators!

THOMPSON TOOL CO.
IOWA PARK, TEXAS

KEEPS DRILLING MUD CLEAN — PROVIDES *TRUE SAMPLES* OF CUTTINGS



Hot Oil Treatment for Steel Muscles

THIS 82-PAGE BOOK ON WIRE ROPE IS FREE. WRITE FOR YOUR COPY TODAY!

Thousands of wire rope users have found that the information packed in the pages of "Know Your Ropes" has made their work easier. It's full of suggestions on proper selection, application and usage of wire rope. It's easy-to-read and profusely illustrated. For your free copy, write—Wire Rope Sales Office, Wickwire Spencer Steel, Palmer, Mass.

Field lubrication of wire rope does much to prevent friction and corrosion, but it is only a surface treatment. To provide proper *internal* lubrication, every strand of Wickwire Rope is actually formed in a stream of hot lubricant. This quick-setting lubricant packs the many spaces between the wires of the strand.

Fiber cores, too, are saturated with a compound that lubricates the strands during the service life of the rope. This built-in protection is the result of years of study to develop a lubrication system that would protect ropes against friction, corrosion and other factors which bind ropes and result in loss of strength and rope life.

Thorough lubrication is only one step in the quality control of Wickwire Rope manufacture—but we at Wickwire believe that *every* step is important to assure finished rope that will provide the utmost in performance, safety and long life.

Wickwire Distributors and Rope Engineers are always ready to help solve your wire rope problems and supply the right rope for your needs. Wickwire Rope is available in all sizes and constructions, both regular lay and WISSCOLAY *Pre*formed.

WICKWIRE ROPE

CF&I & SUBSIDIARIES

A PRODUCT OF THE WICKWIRE SPENCER STEEL DIVISION OF THE COLORADO FUEL AND IRON CORPORATION

WIRE ROPE SALES OFFICE AND PLANT—Palmer, Mass. **EXECUTIVE OFFICE**—500 Fifth Avenue, New York 18, N. Y.

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PACIFIC COAST SUBSIDIARY—The California Wire Cloth Corporation, Oakland 6, California

Associations

PLAN GAS COURSE—Plans have been completed for the 23rd annual Southwestern Gas Measurement Short Course at the University of Oklahoma, Norman, Okla., April 13-15. E. C. McAninch, Oklahoma Natural Gas Company, Ardmore, Okla., is chairman of the general committee. Members of the committee are shown, left to right, George E. Greiner, Phillips Petroleum Company, Bartlesville, Okla.; Cade C. Clover, American Meter Company, Tulsa; W. H. Woods, Gulf Oil Corporation, Houston; K. R. Tibbets, Sinclair Prairie Oil Company, Tulsa; Roland O. Cox, Lone Star Gas Company, Dallas; R. M. Scofield, Lone Star Gas Company, Dallas; Gilbert Estill, Oklahoma Natural Gas Company, Tulsa; Dean W. H. Carson, University of Oklahoma; E. C. McAninch, Oklahoma Natural Gas Company, Ardmore, Okla.; Miss Kate A. Niblack, Oklahoma Utilities Association, Oklahoma City; C. A. Gibson, Cities Service Gas Company, Wichita, Kansas; T. S .Whitis, Amarillo Oil Company, Amarillo, Texas; W. A. Brewster, Arkansas Louisiana Gas Company, Shreveport; J. L. Griffin, Northern Natural Gas Company, Omaha, Neb.; Lloyd L. Jordan, Shell Oil Company, El Dorado, Ark.; B. F. Worley, United Gas Corporation, Houston; E. L. Stark, The Foxboro Company, Dallas. Left corner: C. E. Terrell, Southern Natural Gas Company, Birmingham. Right corner: M. D. Gilbert, Pittsburgh Equitable Meter Division, Rockwell Manufacturing Company, Tulsa; and Earl Kightlinger, Arkansas Louisiana Gas Company, Shreveport.

Worldwide Petroleum Situation Given Major Attention at AIME Sessions

The worldwide petroleum situation, with particular reference to foreign oil, played a major part in discussions before the Petroleum Division, AIME, at the annual meeting in New York, February 15-18.

H. J. Struth, Dallas, and J. Ed Heston of Petroleum Advisers, Inc., New York, presided over the petroleum economics program which was highlighted by a talk by Frank A. Howard of Standard Oil Company (N. J.) on developments in the gasification of coal to obtain liquid hydrocarbons; a discussion by C. J. Bauer on the place Middle East oil will occupy in world markets; and a talk by M. G. Gamble on petroleum transportation with particular reference to tankers.

Bauer, of the petroleum economics division of Standard Oil Company (N. J.), visualized a growth in demand of 16.4 percent in the Western Hemisphere and 42.8 percent in the Eastern Hemisphere with a world increase of 23.4 percent by 1951. It is assumed that by that time the movement of crude from principal producing sources in the world will have been somewhat re-routed, so that for the most part each hemisphere will take care of its own needs except for a few special products. He still sees the Caribbean area as the most important single foreign source, estimating that the Middle East will be producing something like 1,600,000 barrels daily in 1951, against the Caribbean's 1,684,000 barrels daily, although the latter would be producing its reserves at a higher rate. By that time it is estimated that the U. S. will have become a net importer of crude and products to the extent of about ½ million barrels daily.

J. E. Brantley of Drilling and Exploration Company, Dallas, the principal speaker at the annual dinner on February 17, discussed the development of resources in foreign countries by expatriate personnel and capital.

Petroleum Division officers installed at the annual dinner were I. W. Alcorn, The Pure Oil Company, Houston, chairman; Carlton Beal, consultant, Los Angeles, and Paul Fitzgerald, Dowell Incorporated, Tulsa, as vice chairmen. Members of the executive committee for 1948 are, in addition to the new officers: Howard C. Pyle, president of Continental Consolidated Corporation, the outgoing chairman; W. V. Vietti and S. E. Buckley of Houston; W. W. Porter II and John Sherborne of Los Angeles; John Murrell of Dallas, and Benjamin C. Craft of Baton Rouge.

Mid-Continent API Production Meeting Papers Abstracted

The Mid-Continent district, Division of Production, API, held its annual spring meeting March 24-26 at Wichita, Kansas. W. L. Horner, chief engineer, Barnsdall Oil Company, Tulsa, and H. E. Zoller, president, Derby Oil Company, Wichita, presided at the opening session at which C. S. Ritchie, mayor of Wichita, welcomed the several hundred engineers and oil operators who attended the session. Discussions and papers on new drilling and production methods as well as papers on secondary-recovery operations featured the three-day agenda.

Below are abstracts of some of the papers presented during the session:

Desirable Characteristics and Design of Oil Well Pumping Units and Engines

By J. C. SLONNEGER, The Continental Supply Company, Dallas.

Although the industry has made some effort to standardize oil well pumping units, it remains for the engineer to establish the best means for assuring the most desirable characteristics in the design of units and engines. Such standardization as has been adopted pertains primarily to the testing and rating of engines. Although standardization is recommended, the writer states that sufficient latitude should be allowed the engineer to employ his ingenuity in achieving the best results in connection with many of his pumping problems. The paper cites some typical examples in connection with sucker rod pumping, vibration and polish rod load and presents views on what the author considers the most desirable characteristics in use and design to assure optimum service and efficiency.

Factors Affecting the Calculation of Peak Crankshaft Torque from Polish Rod Dynamometer Cards

By HAROLD S. KELLY, M. H. HALDERSON, P. A. WITHERSPOON and E. S. CALVERT, Phillips Petroleum Company, Bartlesville, Okla.

Extensive beam pumping tests were conducted in 1940 on a well in the Oklahoma City pool. Simultaneous measurements were made of polish rod load and crankshaft torque. Other measurements taken permitted calculation of the angular acceleration of the walking beam and the crank. Using the data obtained on these tests, an investigation was made of the factors involved in the calculation of peak crankshaft torque from polish rod dynamometer cards. The results of this torque study are presented. The paper includes discussions of unit geometry, beam off-balance, inertia effects on rotary counterweighted pumping units and inertia effects on beam counterweighted pumping units. It is concluded that there are many pumping units in

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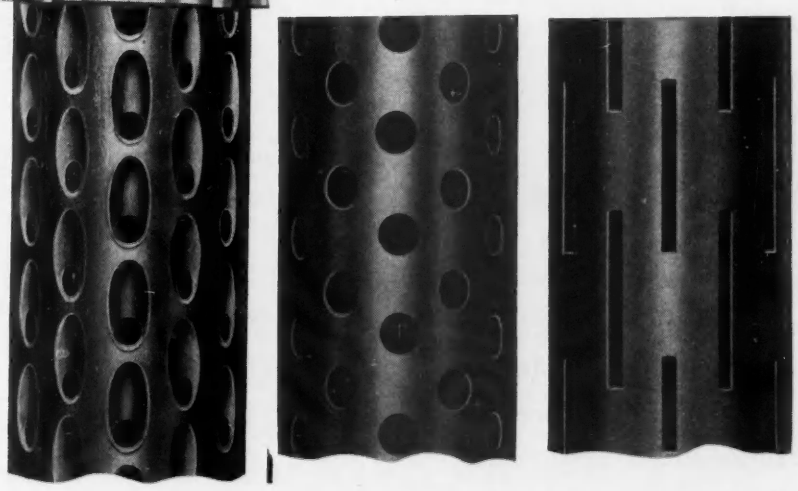

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operation where peak crankshaft torque can be determined with acceptable accuracy and that the oil industry needs a simpler and more economical method for obtaining peak crankshaft torque.

Some Results of Secondary Recovery and Related Problems

By D. B. TALIAFERRO, U. S. Bureau of Mines, Bartlesville, Okla.

The paper reviews briefly results obtained by applying secondary recovery methods to a few projects in the Mid-Continent area and discusses some of the problems met in these operations. Data presented are taken from published articles, but where possible, results have been brought up to date. Projects described include gas injection operations in the North Burbank pool, Osage County, Oklahoma, and in the eastern part of the Delaware Childers pool, Nowata County, Oklahoma, and two small water-flooding projects in Nowata County, Oklahoma, and Archer County, Texas. Because of the greatly increased interest in secondary recovery operations resulting from the higher price of crude and the increasing cost of finding new reserves the writer feels that data will be of interest to many operators who have not been intimately associated with secondary recovery methods of oil production.

Recent Developments in Recommended Field Practice on Care and Use of Oil Country Tubular Goods

By HERBERT M. COOLEY, Bethlehem Steel Company, Tulsa, Okla.

Recent developments of importance on the care and use in the field of oil country tubular goods are the timely revision of the API bulletin on recommended practice RP 5-C-1, and the work done on drill string research by Battelle Memorial Institute for the American Association of Oilwell Drilling Contractors. The need for widespread publicity on the subject and the effectiveness of a paper in reaching those who will be benefited most are suggested. The paper stresses certain points brought out in both the revised bulletin and the drill string reports, and suggests the introduction of other revisions not covered or insufficiently covered at the present time.

Statutes Relating to Secondary Recovery Operations

By ROBERT E. HARDWICKE, Lawyer, Fort Worth, and WALTER L. SUMMERS, Lawyer, Urbana, Ill.

The paper sets forth a comprehensive compilation of the statutes which relate clearly to the general subject of secondary recovery. It makes no attempt to determine the meaning nor to interpret the statutes. It includes a statement concerning terminology and points out that the terms "secondary recovery methods" and "secondary recovery operations" have been used loosely by the industry. A glossary of terms and definitions is given as an appendix to the paper. Statutes are presented which have been enacted in Alabama, Arizona, Arkansas, California, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Montana, New Mexico, Nebraska, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Washington and Wyoming, as well as those adopted by the federal government.

Public Mobile Telephone Service

By R. S. JOHNSON, Southwestern Bell Telephone Company, Kansas City, Mo.

Public mobile telephone service is a switched service similar to regular local telephone service. Several customers share the same radio channel. The user may communicate with any other telephone which is connected with the general telephone system, including other mobile telephones. The service is designed for vehicles operating in cities and on highways and for boats operating on adjacent inland waterways and adjacent harbor waters as well as for boats in coast and harbor waters and for aircraft. The paper describes the scope of service, classes of service, urban and highway radio frequencies, facilities and equipment, method of operation and rates and charges.

Students Hear VanDyke

Orien VanDyke of Houston spoke on drilling mud problems at the February meeting of the Petroleum Engineering Club of Texas A & M College, an affiliated student chapter of the AIME.

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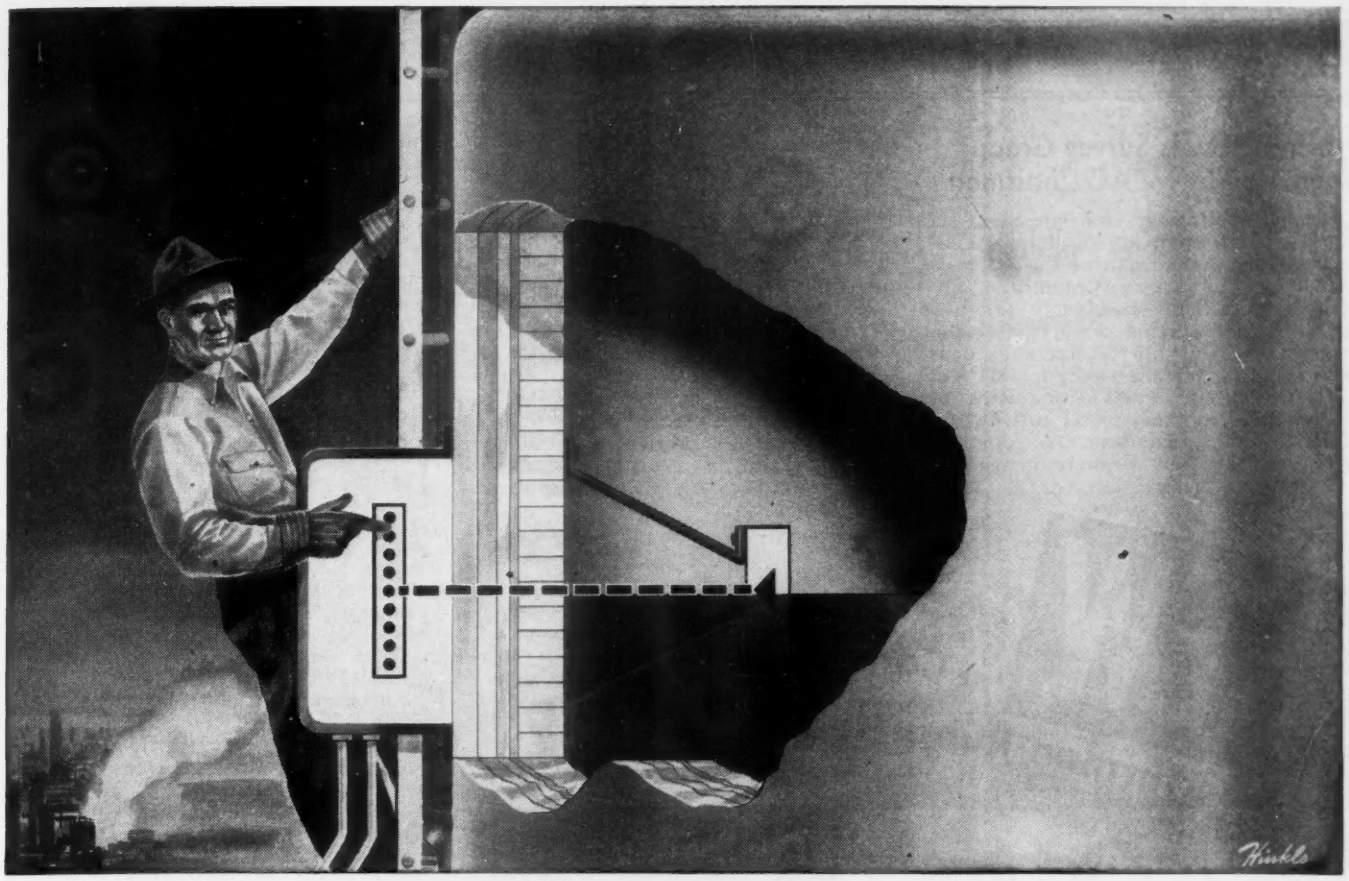

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Synthetic Fuels Survey Group Appointed by MPAC Chairman

Bruce K. Brown, vice president of Standard Oil Company (Indiana), Chicago, Ill., and chairman of the Military Petroleum Advisory Committee, announced members of industry committees who are making a survey of the significance of synthetic fuels in connection with national security for MPAC.

The Synthetic Fuels Committee of MPAC falls in the general jurisdiction of R. G. Follis, Standard Oil Company of California, San Francisco, who is chairman of the Refining Panel of MPAC. These committeemen, after being nominated by MPAC, were specially appointed for this service by the Army-Navy Petroleum Board and the Department of the Interior.

Committee members are as follows:

Synthetic fuels committee — A. P. Frame, Cities Service Research and Development Company, New York, N. Y., who is also a member of MPAC, chairman; Alois Kremser, Standard Oil Company of California, San Francisco; Max B. Miller, Max B. Miller and Company, New York; E. V. Murphree, Standard Oil Development Company, New York; and J. K. Roberts, Standard Oil Company (Indiana), Chicago.

Subcommittee on natural gas—J. K. Roberts, chairman. Reserves group: H. D. Hancock, Cities Service Oil Company, New York, group chairman; R. O. Garrett, Arkansas Louisiana Gas Company, Shreveport; K. C. Heald, Gulf Oil Corporation, Pittsburgh; D. P. Olcott, Humble Oil Refining Company, Houston; T. W. Johnson, Union Producing Company, Shreveport; T. V. Moore, Standard Oil Development Company, New York; and A. M. Ripple, Phillips Petroleum Company, Bartlesville, Okla. Process group: L. C. Kemp, Jr., The Texas Company, New York, group chairman; J. H. Arnold, Hydrocarbon Research, Inc., New York; H. Z. Martin, Standard Oil Development Company, Elizabeth, N. J.; J. E. Rouse, Stanolind Oil and Gas Company, Tulsa; and H. H. Storch, U. S. Bureau of Mines, Pittsburgh.

Subcommittee on coal—E. V. Murphree, chairman, Reserves and mining group: Joseph Pursglove, Jr., Pittsburgh Consolidation Coal Company, Pittsburgh, group chairman; I. N. Bayless, The Union Pacific Coal Company, Omaha, Neb.; J. D. Doherty, U. S. Bureau of Mines, Washington, D. C.; G. C. Gester, Standard Oil Company of California, San Francisco; and M. H. Forester, Pittsburgh Consolidation Coal Company, Pittsburgh. Process group: E. J. Gohr, Standard Oil Development Company, New York, group chairman; E. T. Layng, Hydrocarbon Research, Inc., New York; W. C. Schroeder, U. S. Bureau of Mines, Washington, D. C.; J. E. Seebold, Standard Oil Company (Indiana), Whiting, Ind.; and H. S. Turner, Pittsburgh Consolidation Coal Company, Library, Penn.

Subcommittee on shale—Alois Kremser, chairman. Mining and disposal group: Joseph Pursglove, Jr., group chairman; I. N. Bayless; E. D. Gardner, U. S. Bureau of Mines, Denver, Colo.; G. C. Gester; and A. C. Rubel, Union Oil Company of California, Los Angeles. Process group—Alois Kremser, group chairman; H. G. M. Fischer, Standard Oil Development Company, New York; A. C. Rubel; W. C. Schroeder; and T. P. Simpson (L. P. Evans, alternate), Socony-Vacuum Laboratories, Paulsboro, N. J.

Texas Mid-Continent Group Names Advisory Committee

Five members of the Texas Mid-Continent Oil & Gas Association were named to serve as the advisory committee from the association to the Interstate Oil Compact Commission for 1948, Charles E. Simmons, Mid-Continent vice-president and general manager announced.

The committee will be composed of Curtis Condra, Stanolind Oil & Gas Company, Fort Worth, chairman; A. E. Groff, Shell Oil Company, Houston; Marshall Newcomb, Lone Star Gas Company, Dallas; Scott Myers, Unity Oil Company, Beaumont; Jay Taylor, Baker and Taylor Drilling Company, Amarillo.

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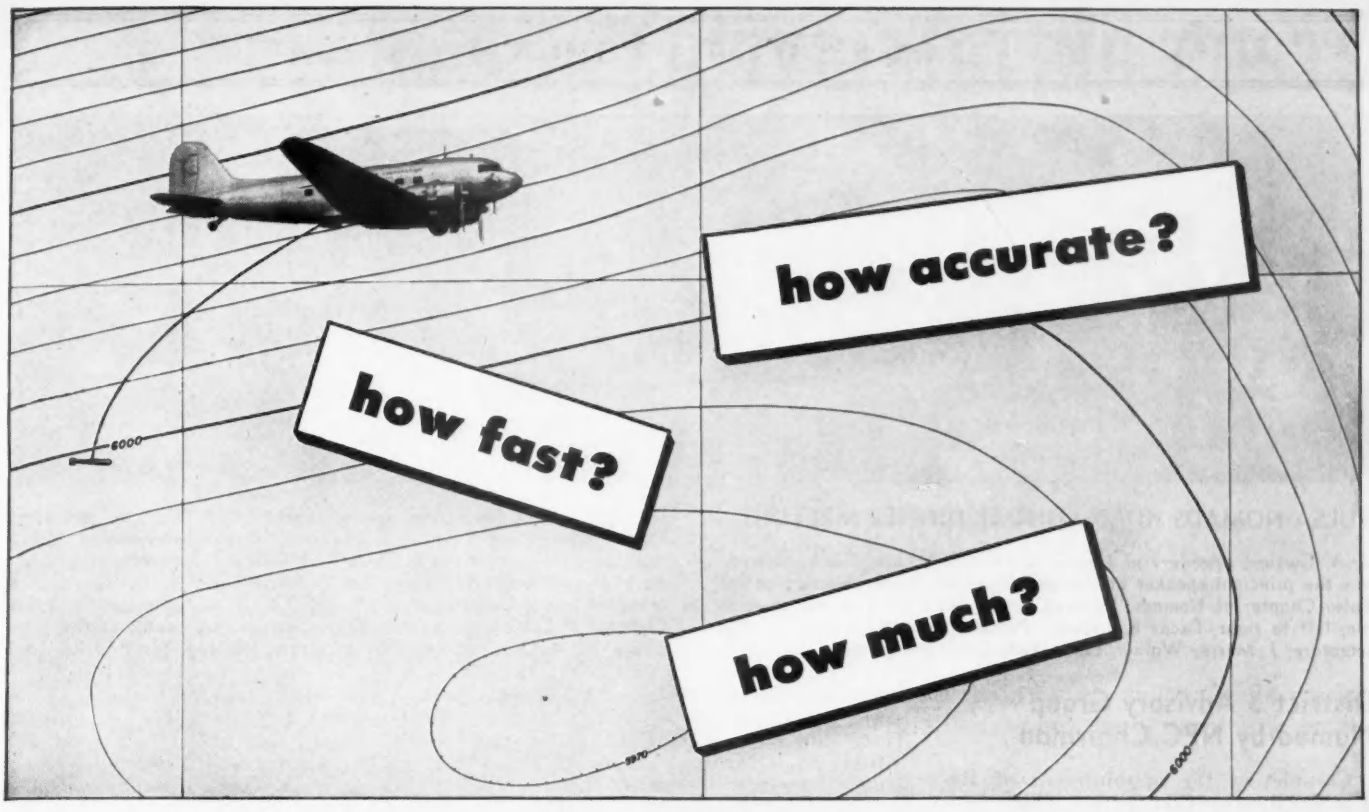

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TULSA NOMADS HOLD ANNUAL DINNER MEETING—

A. A. Curtice, president of Hoover, Curtice and Ruby, South America, was the principal speaker at the eighth annual dinner meeting of the Tulsa Chapter of Nomads. Pictured at the head table at the meeting are, left to right, Oscar B. Irizzary, *Petroleo Interamericano*, assistant secretary; J. Murray Walker, Lane-Wells Company, treasurer; Henry A. Bourne, Republic Steel Corporation, regent; A. A. Curtice, president, Hoover, Curtice and Ruby; P. E. Fitzgerald, Dowell Incorporated, chairman, program committee; M. D. Gilbert, Rockwell Manufacturing Company, chapter president; Mayor Lee C. Price, Tulsa; K. O. Hoevel, The National Supply Company, vice president; H. A. Heller, president, Tulsa Chamber of Commerce; John Pearce, manufacturers' representative, secretary; H. M. Cosgrove, executive secretary, National Board of Regents.

District 3 Advisory Group Named by NPC Chairman

Completing the appointment of Regional Advisory Committees which were authorized by the National Petroleum Council, the chairman, Walter S. Hallanan, appointed from the industry a committee for District 3 which will be instrumental in bringing relief to areas suffering from the existing shortage of fuel and heating oils.

The chairman said that District 3 is primarily a source of supply but should it develop that distribution problems within the district must be considered, this committee will be expanded to include representatives of the distribution and marketing branches of the industry in that district.

Those states in District 3 are Alabama, Mississippi, Louisiana, Arkansas, Texas and New Mexico.

John W. Newton, Magnolia Petroleum Company, Beaumont, Texas, will act as chairman. Those named to the committee are R. B. Anderson, Waggoner Estate, Vernon, Texas; Robert O. Anderson, Malco Refineries, Inc., Roswell, N. M.; Hines H. Baker, Humble Oil & Refining Company, Houston; John A. Bartlett, American Mineral Spirits Company, Corpus Christi, Texas; M. W. Boyer, Esso Standard Oil Company, Baton Rouge, La.; J. M. Bradshaw, Hercules Oil Company, Dallas; C. M. Bryson, McMurrey Refining Company, Tyler, Texas; Joe Hyer, Root Petroleum Company, Shreveport; Parker Kendall, Sinclair Refining Company, Houston; H. S. Lane, Crown Central Petroleum Corporation, Houston; L. D. Mann, Cities Service Refining Corporation, Lake Charles, La.; T. M. Martin, Lion Oil Company, El Dorado, Ark.; G. L. Rowsey, Taylor Refining Company, Taylor, Texas; T. E. Swigart, Shell Pipe Line Corporation, Houston; Raymond L. Tollett, Cosden Petroleum Corporation, Big Spring, Texas; and F. L. Wallace, The Texas Company, Port Arthur, Texas.

Oil Congress and Forum Assured for Exposition

A world-wide petroleum congress, as well as a world's fair of the oil industry, will be held in conjunction with the silver anniversary of the International Petroleum Exposition opening at Tulsa May 15, according to W. G. Skelly, president.

Alf G. Heggem

Skelly confirmed official appointment of Alf G. Heggem, Tulsa petroleum engineer and industrialist, as chairman of the "International Petroleum Exposition Congress."

Heggem is one of the founders of the exposition. He has been an officer, as well as an exhibitor, in every oil show since 1923, when the International Petroleum Exposition and Congress was incorporated as a non-profit educational institution.

Meetings of the oil congress will be of the open forum type. Many will probably be held in the dining and meeting rooms available in the Tulsa Building at 5th and Cincinnati. World-wide attendance and participation by governmental officials, oil, equipment, supply and engineering executives who operate internationally is already assured, exposition officials declared.

Petroleum scientists and technicians are equally as eager for the congress, according to Dr. B. B. Weatherby, chairman of the IPE Scientific and Technical committee.

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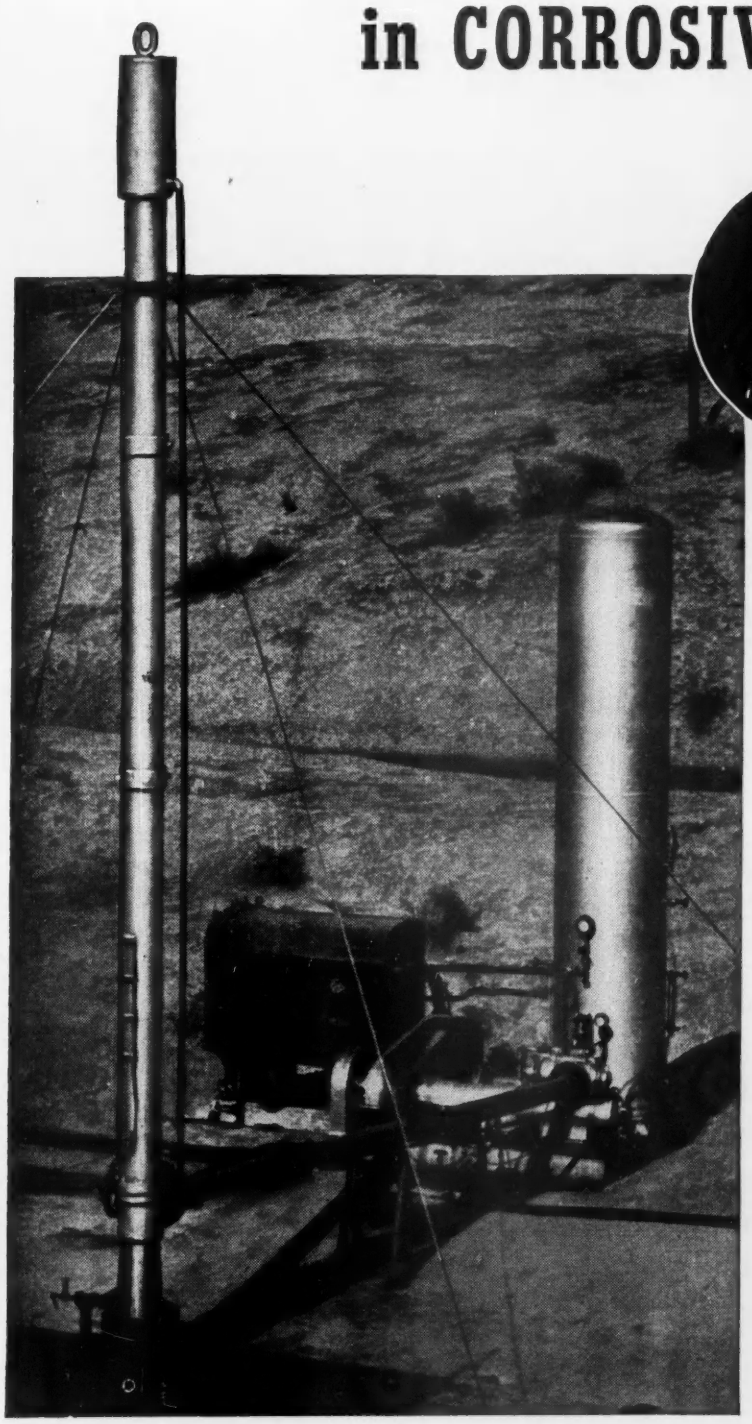

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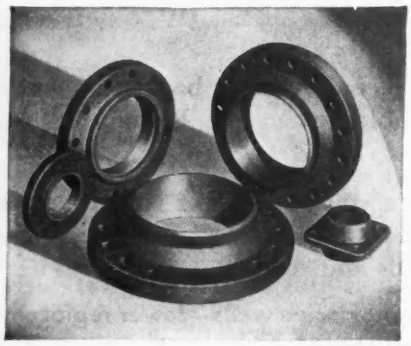
Rocky Mountain Topics to Be Stressed at AAPG Convention

The 33rd annual meeting of the American Association of Petroleum Geologists will be held in Denver, April 26-29. Concurrently, the 22nd annual meeting of the Society of Economic Paleontologists and Mineralogists and the 18th annual meeting of the Society of Exploration Geophysicists will convene. Headquarters for the meetings of the American Association of Petroleum Geologists will be in the Shirley-Savoy Hotel, and meetings of the other two organizations will be held in the Cosmopolitan Hotel.

The technical program is to include papers pertaining to the Rocky Mountain area except in a few cases of a special interest to geologists at the present. The technical program will begin Monday, April 26, with a paper on the hydrogenation of coal by V. F. Parry of the U. S. Bureau of Mines coal research station on the campus of the Colorado School of Mines at Golden. Tuesday morning will be devoted to the opening of the convention, including the presidential addresses for the three societies and the presentation of the various awards. The afternoon session will include papers on the occurrence of oil in the Arbuckle and Ellenburger formations, on the "Golden Trend" of McLain and Garvin counties, Oklahoma, and on the Leduc oil field of Alberta, Canada.

Wednesday, and perhaps part of Thursday, will be devoted to a symposium of the Rocky Mountain region, in which general papers will be given on the orogeny of the Front Range and on a resume of oil-finding. Regional and statewide papers will be given on the stratigraphy and paleogeography of Colorado, Wymoing, Utah, and Montana, and adjacent areas. At the evening meeting, it is planned to have a paper on the Middle East oil fields and their reserves.

On Thursday, papers will include one on coral-reef production at several localities, one on the Permian Basin, and one on gas resources. Several short papers are planned on the geology, paleontology, and oil prospects of Naval Petroleum Reserve No. 4 in northern Alaska. The annual business meeting for the American Association of Petroleum Geologists is scheduled for Thursday also.



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47 Officers Attend Shell's Basic Petroleum School

Forty-seven officers of the armed forces are attending the second class of the Basic Petroleum School conducted by Shell Oil Company at the Industrial War College in Washington, D. C. The purpose of the school is to give certain key military personnel a general knowledge of the manufacture, application, and handling of petroleum products.

According to Major General T. B. Larkin, quartermaster general, who formally opened the school, the training program is a gratifying example of cooperation between the oil industry and the armed forces. In view of the proved importance of oil during the war, the school is considered a valuable contribution of the oil industry's specialized knowledge to military organizations.

Shell established the school at the request of the armed forces after more than a score of officers had attended a similar three-week course conducted last year for its own personnel at Katonah, N. Y. In charge of the course is Dr. G. P. Koch, director of education at Shell, who was loaned to the Navy and Air Force for instructional purposes several times during the war.

Seminole API Elects

Harold Spillers, superintendent for The Carter Oil Company, in the Seminole, Okla., district, has been elected chairman of the new Seminole Chapter, API. Other officers include Tom Trax, assistant superintendent, Gulf Oil Corporation, first vice chairman; R. D. Michaels, co-owner of Michael Bros. Construction Company, second vice chairman, and Rogert Frazier, district engineer, The Carter Oil Company, secretary-treasurer.

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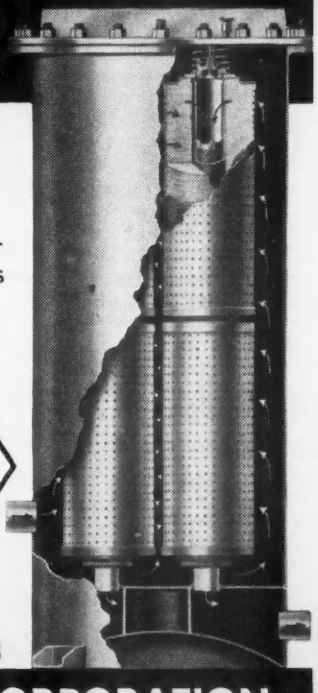

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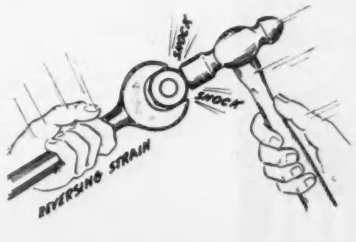
A drilling contractor on a barge location in South Louisiana, drilling below 9000 feet with 16# mud, stuck 4½" o.d. drill pipe near bottom. A Kinley Back-Off Shot was made at 8,600 feet, while reversing strain was held on the pipe, and the joint was broken at that depth.

The sketch below, which is familiar to everyone who has broken out a pipe joint, illustrates the effect of the Kinley Back-Off Shot. The explosive is only of sufficient force to apply a non-damaging shock to the joint while reversing strain is held on the pipe. The shot is safe and easy to make, utilizing either a Halliburton line with go-devil or an electric line.



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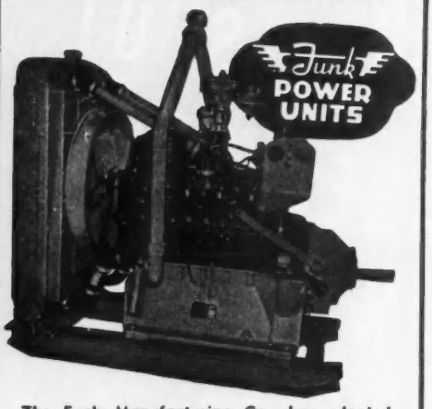

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ASSOCIATIONS

Trade-Mark of Petroleum Exposition Made Available

Officers and directors of the International Petroleum Exposition and Congress have released one of the official 25th Anniversary Exposition trade-marks.

Trade journals, oil company employe publications, petroleum engineering organizations, oil equipment and supply concerns and others connected with the petroleum industry are being urged to use the trade-mark for the attendance-building campaign to the eight-day exposition and international petroleum congress which opens May 15.

Various sizes of the IPE trade-mark in electros, mats, glossy prints and engravers proofs are available for use as "drop-ins" for current advertising, use on letterheads, envelopes, packages, labels and direct mail inserts.

The accompanying trade-mark may be obtained without cost by calling William B. Way, general manager of the exposition at 9-4977, Tulsa, or writing him at P. O. Box 978, Tulsa.

Ohio Area Producers Attend Forum at Marietta College

Dr. E. S. Merriam, natural gas consultant and a member of the faculty of the Edwy R. Brown School of Petroleum, Marietta College, Marietta, Ohio, spoke on "Power" before a forum of oil and gas producers. The meeting was sponsored jointly by the college and the Ohio Gas and Oil Association.

Other speakers and their topics were Bruce F. Grant, petroleum engineer with the U. S. Bureau of Mines, Franklin, Penn., "Oil Well Cleaning Out Methods"; W. B. Stamford, National Supply Company, Pittsburgh, "Electrical Pumping Installations"; J. B. Corrin, Jr., The River Gas Company, Marietta, "Storage of Gas in Natural Reservoirs"; Kent Lehmer, Producers Torpedo Company, Marietta, "Marble Shoooting"; Jack Cashell, Preston Oil Company, Columbus, Ohio, "Secondary Recovery in Ohio"; George Dougan, petroleum student at Marietta College, "Emergency Pipelines."

L. T. Gibbs Named President Of Tulsa Engineers Club

Lloyd T. Gibbs of the Lloyd T. Gibbs Company, has been elected president of the Engineers Club of Tulsa for 1948-49. He is a native of Nebraska and graduated from the University of Lincoln with a degree in electrical engineering.

Other officers include Lloyd Elkins, chief engineer, Stanolind Oil & Gas Company, executive vice president; Carl A. Stevens, consulting engineer, treasurer; W. E. Kennebrew, Dresser Engineering Company, vice president in charge of entertainment; J. Murray Walker, Lane-Wells Company, vice president for membership; M. J. Myers, Jr., Public Service Company of Oklahoma, vice president for programs; Max R. Wise, manufacturers' representative of St. Louis Steel Casting Company, vice president for public relations. New directors include C. B. Gannaway, Jr., retiring president who is plant manager for Flint Steel Corporation; Raymond M. Carr, Sinclair Prairie Oil Company, and L. L. Dresser, Dresser Engineering Company.

THE OIL MAN'S CALENDAR

APRIL 5- 8	National Association of Corrosion Engineers, Annual Meeting, St. Louis, Hotel Jefferson.
6	American Association of Oil Well Drilling Contractors, Directors' Meeting, New Orleans.
6- 7	Michigan Petroleum Association, Annual Spring Convention, Detroit, Detroit Leland Hotel.
8-10	Mid-West Gas Association, Annual Meeting.
14-16	American Petroleum Institute, Southwestern District Meeting, San Antonio, Plaza Hotel.
21-23	National Petroleum Association, Cleveland, Hotel Cleveland.
25-27	Independent Petroleum Association of America, Mid-Year Meeting, Wichita, Kansas, Broadview Hotel.
26-29	American Association of Petroleum Geologists, Society of Economic Paleontologists & Minerologists, Society of Exploration Geophysicists, Annual Meeting, Denver, Shirley-Savoy Hotel.
27-28	Mid-Continent Oil & Gas Association Federal Tax Forum, Fort Worth, Blackstone Hotel.
28-30	Liquefied Petroleum Gas Association, Annual Convention and Trade Show, Kansas City, Mo.
MAY 4- 5	American Gas Association, Natural Gas Department, Annual Spring Meeting, Houston, Rice Hotel.
5- 7	Interstate Oil Compact Commission, Spring Quarterly Meeting, Chicago, La Salle Hotel.
6- 7	American Petroleum Institute, Pacific Coast District Meeting, Los Angeles, Biltmore Hotel.
15-22	International Petroleum Exposition, Tulsa.
27-28	Natural Gas & Petroleum Association of Canada, Niagara Falls, Ont., General Brock Hotel.
JUNE 6- 8	Petroleum Equipment Suppliers Association, Colorado Springs, Colo., Broadmoor Hotel.
JUNE 30 July 2	American Petroleum Institute, Eastern District Meeting, White Sulphur Springs, W. Va., Greenbrier Hotel.
JUNE 30 July 3	Canadian Gas Association, Annual Convention, Jasper, Alberta, Jasper Park Lodge.
SEPT. 15-17	National Petroleum Association, Atlantic City, N. J., Hotel Traymore.
OCT. 4- 9	American Gas Association, Atlantic City.
NOV. 7- 8	American Association of Oilwell Drilling Contractors, Annual Meeting, Houston.
8-11	American Petroleum Institute, Annual Meeting, Chicago, Stevens Hotel.

Nomads Chapter monthly meetings: **Los Angeles,** second Wednesday, Jonathan Club, B. M. Landis, Secretary. **Houston,** second Monday, Houston Club, Harry E. Estes, Secretary, Telephone Charter 4-7611. **Dallas,** L. A. Little, Secretary, Telephone Justin 8-1726. **Tulsa,** third Wednesday, Hotel Tulsa, Anthony Gibbon, Secretary, Telephone 3-1844. **New York,** first Monday, Louis Sherry's, Norris Boulden, Secretary, Telephone WIckersham 2-1311, extension 260.

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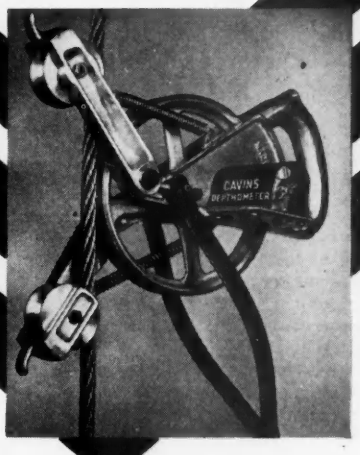

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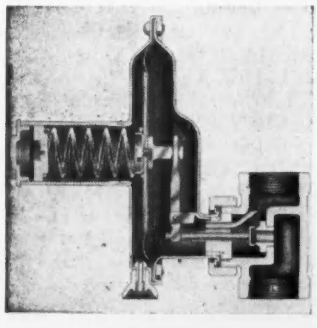

Vertical diaphragm prevents water, oil or butane accumulation. Avoids freezing in coldest weather.

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Body easily positioned for any pipe run.

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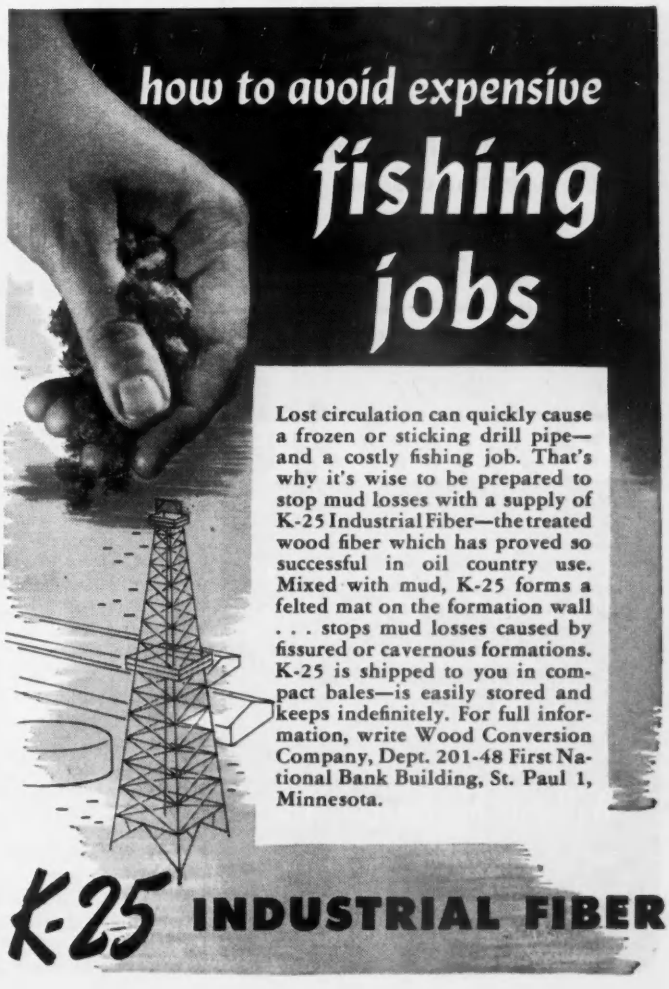
jobs



Lost circulation can quickly cause a frozen or sticking drill pipe—and a costly fishing job. That's why it's wise to be prepared to stop mud losses with a supply of K-25 Industrial Fiber—the treated wood fiber which has proved so successful in oil country use. Mixed with mud, K-25 forms a felted mat on the formation wall . . . stops mud losses caused by fissured or cavernous formations. K-25 is shipped to you in compact bales—is easily stored and keeps indefinitely. For full information, write Wood Conversion Company, Dept. 201-48 First National Bank Building, St. Paul 1, Minnesota.

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Letters TO THE EDITOR

Cost Analyses

Referring to the otherwise excellent article "Application of Pumping Equipment" by K. N. Mills in your February, 1948 issue, the first paragraph, in putting too much emphasis on " . . . the minimum investment," illustrates an all too common fallacy regarding the relative importance of all the factors concerned, especially "efficiency."

The final criterion in the selection of pumping equipment is surely the total cost of producing the oil. In estimating the items concerned, costs should be reckoned over a number of years. The capital investment, if the equipment can only last ten years, must be recovered in ten years, therefore the annual charge for capital depreciation is 10 percent. Adding a charge for interest, the capital investment is then represented as a recurring cost item "interest and depreciation" and added to all the other recurring costs, such as pulling, replacements, repairs, power, cleaning-out jobs, overheads etc. to arrive at a realistic total cost, all items being shown in suitable common terms.

A well-known current advertisement indicates that 15 to 40 percent of operating costs is represented by pulling costs. Although it is not clear what is included in "operating costs," it is probable that in many oil fields the pulling costs make a larger item in the total cost of production than the item "interest and depreciation." It is probable therefore, as an example, that a 50 percent increase in total capital investment, other things being equal, would be profitable if it resulted in a 50 percent reduction in pulling costs.

The whole point is that cost analyses are absolutely necessary if maximum production at minimum cost is the ultimate object.

NORMAN F. BROWN,
N.F.B. Displacement Pump Co., Ltd.
24-28 Lombard Street, London, E. C. 3.

Closed NPC Meetings

WORLD OIL *wrote Secretary of the Interior Krug suggesting that meetings of the National Petroleum Council be opened to the press, under the feeling that in the long run such a procedure would make for better public relations between the Council and its efforts, and the public in general.*

Following is the reply of Secretary Krug, taking a position which, in view of the general situation, is, in our opinion, sound:

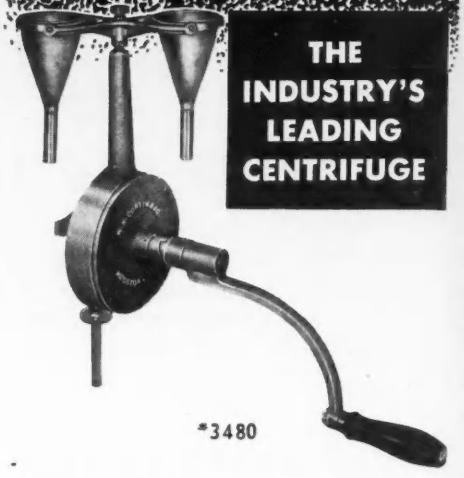
"The matter of opening the meetings of the National Petroleum Council to the press, as suggested in your letter has received a great deal of consideration ever since the formation of the Council, and has been discussed at some length with various members of the press. But every time we review it, we come up with the same answer, namely, that it would be unwise to make the meetings open.

"The chief reason for keeping the meetings closed is not fear of possible garbled accounts, for the trade press representatives in Washington are as competent and as reliable a group of reporters as I have had the good fortune to know, but that opening the meetings to the press would inevitably change the character of the discussions because some members would speak less freely and with more constraint, and other members might succumb to the temptation to address their remarks to the public and not to the meeting.

"It is still my opinion, therefore, that the present system is the better one."

HEAVY DUTY-RUGGED....

THE INDUSTRY'S LEADING CENTRIFUGE



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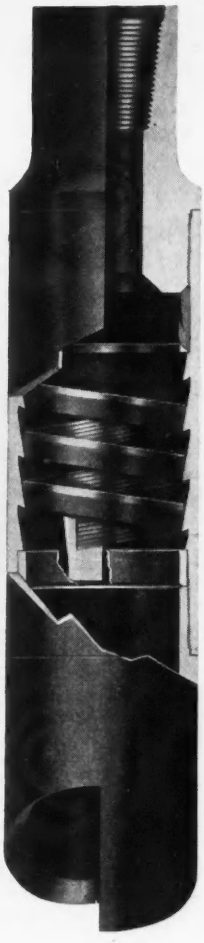

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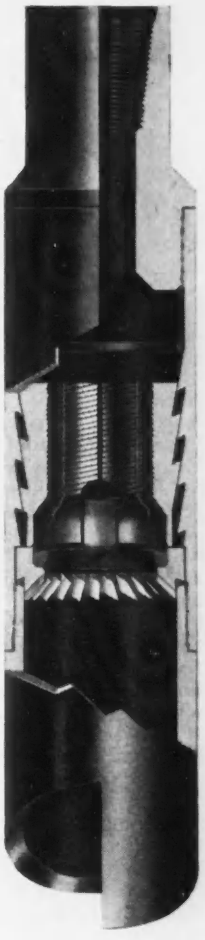
"Series 150" Bowen Overshot shown fitted to catch and packoff 7¾" O. D. Drill Collars.



"Series 150" Bowen Overshot same as on opposite side of ad but fitted with basket type undersized parts to mill over and catch and packoff 4½" O. D. pipe.

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A KNOTT HOTEL—Joseph F. Duddy, *Manager*

Men in the Industry NEWS

Dr. John M. Pearson and **Dr. Ulick R. Evans** have been named recipients of the 1948 awards of the National Association of Corrosion Engineers. Dr. Pearson has been honored with the Frank Newman Speller Award in Corrosion Engineering and Dr. Evans with the Willis Rodney Whitney Award in Corrosion Science. Presentation will be made at the association's annual banquet April 7 at the Hotel Jefferson, St. Louis. Dr. Evans was honored in recognition of his outstanding contributions to the fundamental knowledge on which the practical control of corrosion is based. Dr. Pearson's award was for his outstanding service in the application of scientific research in the prevention of corrosion, particularly by cathodic protection of underground structures. Dr. Evans has been associated with Cambridge University since 1919. Dr. Pearson is director of the Physical division of the Research and Development department of Sun Oil Company.

Dr. John M. Pearson

M. W. (Mel) Fuller has resigned as chief geologist for The Carter Oil Company and will engage in geological consulting work at Tulsa. Fuller joined the Carter staff in 1934 and has seen service in Illinois, Indiana, Kentucky, Michigan, Kansas and Oklahoma.

»

Dale Heltzel, formerly an attorney at Newkirk, Okla., has joined the legal staff of Continental Oil Company at Ponca City, Okla.

»

J. C. (Jean) Finley, chief geologist for Midstates Oil Corporation, Tulsa, has resigned to become manager of exploration for Kerr-McGee Oil Industries, Inc., Oklahoma City. Finley was associated with Midstates since 1937. For eight years prior to that he was in Phillips Petroleum Company's Geological department. He was educated at the University of Kansas.

J. C. Finley

Hillyer Brown, San Francisco attorney, was named a director and vice president of Standard Oil Company of California. **J. L. Hanna** and **J. H. MacGaregill,** vice presidents and directors, retired. **Paul L. Fahrney** was named a vice president and **Marshall Madison,** general counsel. Brown has been a member of the legal firm of Orrick, Dahlquist, Neff, Brown and Herrington, and has engaged in general corporate practice. Hanna joined Standard in 1911 and was named general manager of all refinery operations in 1933. He became a director in 1940 and a vice president in 1941. MacCaregill started with the firm in 1918 and served in a number of marketing postions in Pacific Coast cities. He became a director in 1940 and a vice president in 1941. Fahrney joined Standard as a research chemist in 1920 and in 1942 was named president of American Bitumule Company, a subsidiary. He held this position until his recent appointment as general manager of operations in Standard's marketing department. Madison succeeds the late **Felix Smith** as general counsel. He has been a member of the firm of Pillsbury, Madison and Sutro since 1925.

Hillyer Brown

»

Granville Tierney has resigned as landman for Amerada Petroleum Corporation at Jackson, Miss., and may shortly join an independent oil company in Wichita, Kansas.

»

Robert M. Williams has been named manager of Sohio Petroleum Company's land department in Kansas, succeeding **F. W. Simms,** who resigned to join the Buffalo Oil Company at Dallas.

»

Dempsey A. Winn and **Merle R. Williams** have been named assistant secretary and assistant treasurer, respectively, of Shamrock Oil & Gas Corporation, Amarillo, Texas. The posts were created at the annual meeting of the board of directors. Other officers were reelected as follows: **J. H. Dunn,** president; **Ray C. Johnson** and **Harry Wheeldon,** vice presidents; **F. V. Wallace,** secretary, and **B. E. Tyler,** treasurer.

»

Arville Irving Levorsen, petroleum geologist and head of the School of Mineral Sciences at Stanford University, Calif., has been named recipient of the Sidney Powers Memorial Award of the American Association of Petroleum Geologists. The award is "in recognition of distinguished and outstanding contribution to, and achievements in petroleum geology." This honor will be conferred at the annual meeting of the AAPG in Denver, April 27.

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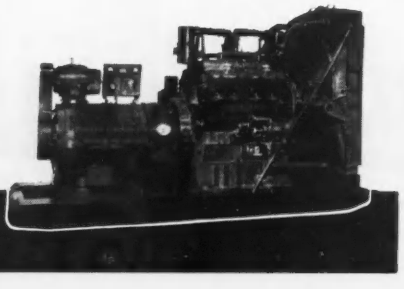

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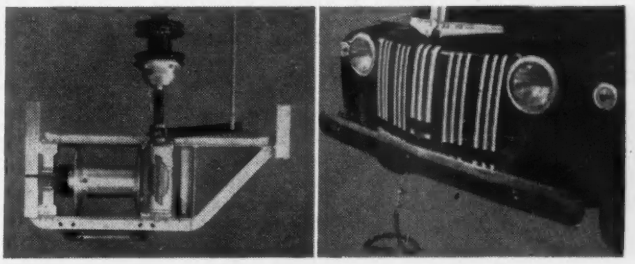

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1. Special mounting frames and other parts are furnished to fit each vehicle, making installation easy for any good garage.

COMPLETE WINCH INSTALLATION WEIGHS 100 lbs.

2. The Ramsey Model 101 Winch is driven from the front end of the crankshaft by an enclosed-self-aligning, jaw clutch which can be disengaged under a load and permits easy changing of fan belts.

NO POWER TAKE-OFF IS REQUIRED.

The Ramsey Winch can be installed easily and quickly on the following cars:

Universal Jeep
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K-1, K-2, K-3 Internationals

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- Save on Pulling Costs
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Protect expensive and hard-to-get steel parts from hydrogen sulphide corrosion and corrosive mine and well waters, with Thompson-Hayward Formaldehyde.

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Available in ½ pint, 1 pint and 1 quart sizes in both single and double-connection styles. Your supply house has them or can secure them for you.

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Max B. Ederington has resigned as superintendent of the Montana-Wyoming division of Interstate Oil Pipe Line Company to become superintendent of the Andean National Corporation in Colombia.

»

William C. Taylor was named a director of the Foreign department of Sun Oil Company. Taylor, who has been acting director of the Foreign department since the death of **John A. Lloyd** last June, has been with Sun since 1933, when he graduated from the University of Pennsylvania. He was named assistant manager of the Foreign department in January, 1946.

Joe Kornfeld, former oil writer-geologist, has joined Sohio Petroleum Company at Oklahoma City, as a reservoir engineer. Before joining Sohio he was with The Texas Company's geological and engineering departments at Fort Worth.

»

Howard T. Jayne, safety engineer of the Philadelphia Gas Works Company, was honored for his contributions to utility safety development during his two-year term as chairman of the Accident Prevention Committee of the American Gas Association.

Howard H. Hinson, formerly assistant supervisor of the U. S. Bureau of Mines' helium plants at Amarillo, Texas, has been named chief engineer for Continental Oil Company's Production Research Section at Ponca City, Okla. Hinson has been with the Bureau of Mines at Amarillo for 12 years and had supervised research in reservoir engineering and natural gas and had charge of all government-owned gas fields and pipe lines supplying gas to helium palnts. In naming the Amarillo man to head up its production research, Continental announced an expansion program in this field with additional personnel to be added.

Howard H. Hinson

»

Albert E. Sweeney, Jr., former field engineer for the Fairbanks Operators Committee, has assumed his duties as director of the Secondary Recovery Division of the Interstate Oil Compact Commission.

»

H. D. Borne of Tulsa was appointed assistant secretary and assistant treasurer of The Texas Pipe Line Company, succeeding the late **B. A. McKerren.** Borne's headquarters will be in Tulsa.

»

Harry C. Hunt and **Richard D. Brigham** were named directors of Tide Water Associated Oil Company. Hunt, a resident of Monterey, Calif., has been identified with the oil industry since 1922. Brigham is a vice president and director of the Anglo-California National Bank of San Francisco.

»

J. Phil McGowan, district landman for Crown Central Petroleum Company at Shreveport, has resigned to join Continental Oil Company at San Antonio.

»

Robert D. Fitting and **J. Robert Jones** have joined the petroleum geology and engineering consulting firm of Ralph U. Fitting, Jr., Midland, Texas. The firm will now be known as Fitting, Fitting and Jones.

»

H. H. Holman has resigned as petroleum engineer in Stanolind Oil & Gas Company's central division to join the consulting firm of Meyer and Achtschin at Dallas.

»

C. O. Crouch, division manager, South Texas division, The Texas Pipe Line Company, and his staff have moved offices from The Texas Company building, San Jacinto and Rusk streets, to the seventh floor, National Standard building, 1006 Main Street, Houston.

Bottom Water is a drain on profits

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To insure an uninterrupted flow of oil from your wells, banish bottom water with economical Eagle Lead Wool. This finely stranded metallic wool, tamped around the hole, effectively seals every crack, becomes a permanent, non-corrosive plug. Packed in convenient 50-pound sacks—easy to place in special cartridge-shaped Eagle Wire Containers sized to fit all casings.

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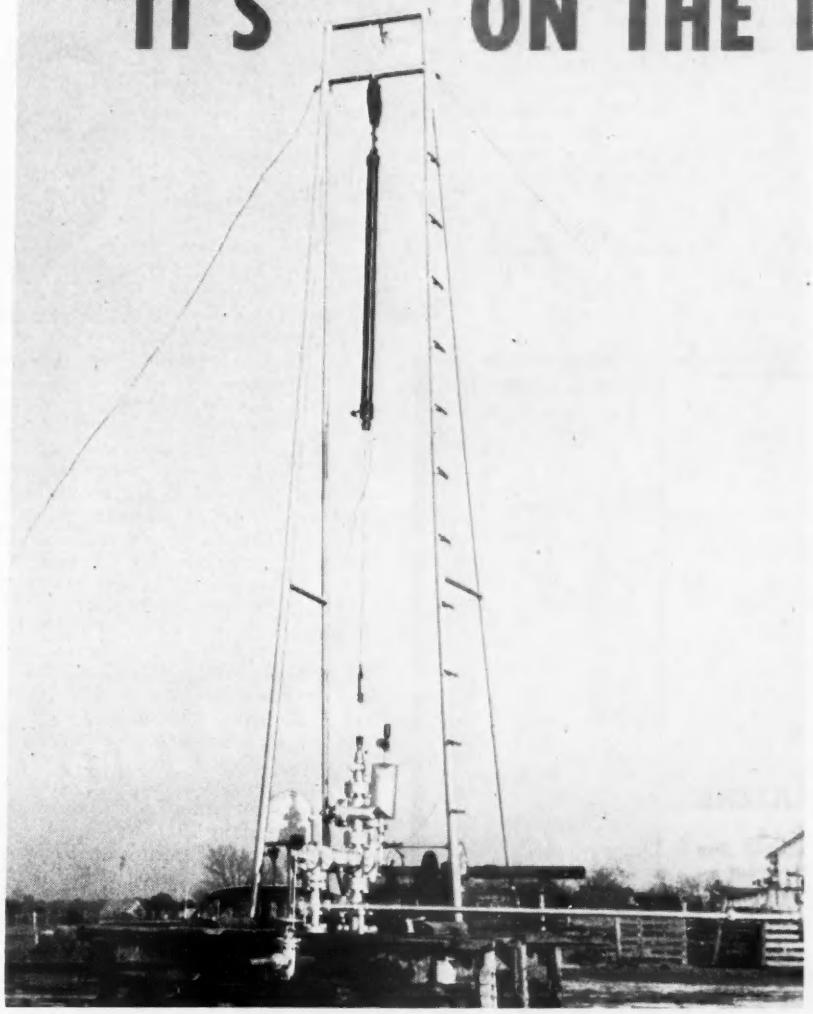

The Nixon Installation shown at the left is in the Villa Platte field—and is producing at 9700 feet.

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J. P. Wasinger, formerly with Orville Glick, has joined Bay Petroleum Corporation as head of the Land department in Wichita, Kansas, succeeding **Clair A. Foster,** who has joined the National Cooperative Refining Company at Wichita.

J. P. Quigley has been named district landman at Wichita, Kansas, for Great Lakes Carbon Corporation.

Robert Galeski, formerly with United Geophysical Company, has joined the staff of Honolulu Oil Corporation at Los Angeles.

Floyd L. Martin has been named executive vice president of Sunray Oil Corporation. He will continue his responsibility as vice president in charge of refining and sales. Martin went to Oklahoma from West Virginia in 1916 and joined Sunray in 1930 to operate the Allen, Okla., refinery. He became a vice president of the company in 1935 and a member of the Sunray board of directors in 1941.

Patrick J. Williams, superintendent of the Austin division for Shell Pipe Line Corporation, has retired after 31 years of service.

Harry Leyendecker, formerly with Tide Water Associated Oil Company and more recently an executive in the Oil and Gas department of the City National Bank, Houston, has become vice president in charge of production for Eastern States Petroleum Company, Houston. He will deal with crude production, development and pipe line problems. Leyendecker resigned from Tide Water in 1946 after 18 years. A native of Temple, Texas, he became a scout in 1926 for Marland Oil Company in Fort Worth and later joined Tidal Oil Company, which became Tide Water Associated. He was chief scout and management assistant when he obtained a leave of absence in 1942 to serve with PAW. He became a director of supply and transportation for District 3 before returning to Tide Water as chief scout and statistician.

Harry Leyendecker

Scott C. Lambert was appointed general tax counsel for Standard Oil Company of California. He will be in general charge of administration of Standard's tax organization.

Lambert, born in Salt Lake City in 1910, joined Standard as a messenger in 1928 and in 1937 was made assistant to the special tax counsel. From 1941 to 1944 he was associated with the law firm of Pillsbury, Madison and Sutro after which he returned as special counsel in the secretary's office of Standard.

George D. Fiser of Shreveport was named general counsel of United Gas Corporation, United Gas Pipe Line Company and Union Producing Company. Fiser is a native of Indiana, graduated with honors from South Texas School of Law at Houston, was admitted to the state bar of Texas, and entered the profession in Houston. He then entered the gas and oil business in Wyoming in 1916. He first became affiliated with a predecessor of United Gas in 1927, serving in various responsible positions for ten years. In 1937, he moved to the Legal department of United Gas Pipe Line Company, in Houston, and moved to Shreveport early in 1940 when the company's offices were moved there.

John T. Oxley of Tulsa has been elected president of the recently-organized Texas Natural Gasoline Corporation, an affiliate of **Edwin B. Cox** and **Jake L. Hamon** of Dallas. Oxley formerly was secretary, assistant treasurer and manager of the gas division for Warren Petroleum Corporation of Tulsa. The Texas Natural Gasoline Corporation was organized to permit Cox & Hamon to become more actively engaged in the gas and natural gasoline phases of the industry.

Tide Cox, Jr., has joined Drilling and Exploration, Inc., of Dallas, and is on a four-year assignment in Brazil. He recently served in Venezuela for the company.

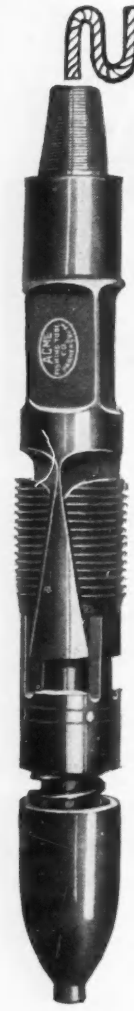

Fig. 247 Acme Trip Casing Spear.

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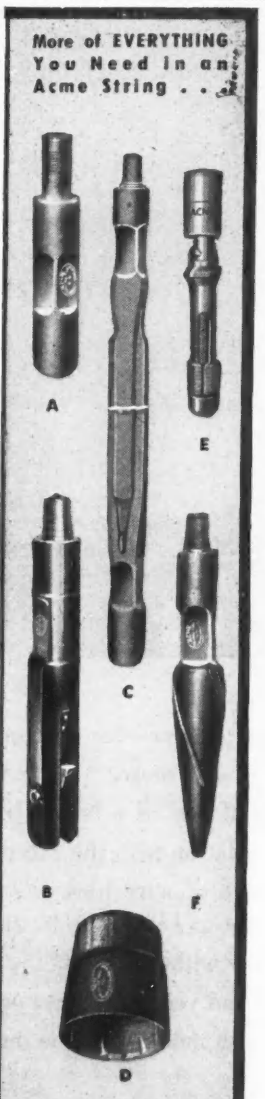

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Check branch of industry

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☐ Producing Company
☐ Pipe Line
☐ Individual Producer
☐ Manufacturing
☐ Supply

Harry D. Campbell has joined Franco Western Oil Company as production engineer. Campbell saw service in both the Atlantic and Pacific theaters as a Navy lieutenant during the war, and has had oil industry experience with Union Oil Company and Stanolind Oil & Gas Company.

⌄⌄

C. Francis Beatty, a member of the board of directors of Socony-Vacuum Oil Company, Inc., has been elected to the board of the National Industrial Conference Board, New York.

George P. Alden, associate petroleum engineer with the U. S. Geological Survey at Tulsa, has resigned to become a petroleum engineer with Barnsdall Oil Corporation.

⌄⌄

J. J. Zorichak, formerly chairman of the Rangely Engineering committee, Rangely, Colo., was named to the staff of the API Division of Production, Dallas. He will assist in administering the engineering and training activities of the division.

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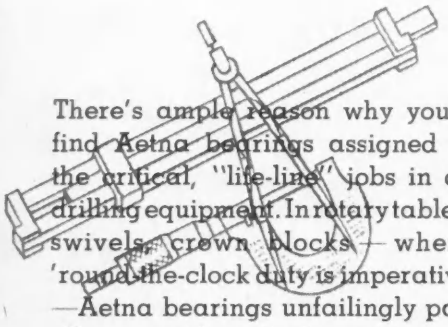

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W. Alton Jones, president of Cities Service Company, was awarded the President's Certificate of Merit for services to the government during the war. Jones was praised for his activities as president of War Emergency Pipelines; chairman of District 1, PAW; and member of PIWC. "To all these undertakings, Mr. Jones brought extraordinary executive talent, unflagging enterprise, and inspiring leadership, resulting in achievements contributing greatly to the national welfare," the citation set forth.

W. Alton Jones

⌄⌄

George A. Musselman has been promoted to chief geologist for The Carter Oil Company, succeeding **M. W. (Mel) Fuller,** resigned. Musselman, former assistant to **Harold F. Moses,** vice president in charge of exploration and research, is a native of Texas and after his graduation from the University of Texas joined Carter in 1939 as junior geologist and was assigned to the Northwest district, later serving in the geological department in Tulsa, St. Elmo, Mattoon and Jackson, Miss.

⌄⌄

Winthrop N. Stivers has been promoted to area engineer of the Wyoming division of Stanolind Oil & Gas Company, with headquarters at Casper, and **Sidney L. Cox** has been named area engineer of the Nebraska division with headquarters at Scottsbluff.

⌄⌄

Mrs. B. D. Less, Dallas, was elected president of the Rinehart Oil News Company, and publisher of Ira Rinehart's Oil Reports, succeeding **Robert H. Richards,** resigned. **E. Redden,** manager of the company's Houston office, was named vice president.

Transfers:

Harry M. Hovis was transferred from Port Neches to Austin, Texas, as superintendent of the Austin division for Shell Pipe Line Corporation; **Clyde P. Wilson** from Healdton, Okla., to Port Neches as superintendent of the Bayou System; **Horace E. White** from Houston to Healdton as superintendent of the Healdton division; **Thomas D. Brown** from head office, Houston, to South Main Street headquarters as assistant to area superintendent, Texas Gulf. **S. E. Elder,** district geologist for Sun Oil Company at Evansville, Ind., to Wichita, Kansas, to open a district office. **B. B. Bradish,** Skelly Oil Company geologist, from Wichita, Kansas, to Albuquerque, N. M. **Sherman K. Jackson** from Fort Smith, Ark., to Oklahoma City to become district engineer for the water resources branch of the U. S. Geological Survey. **Marshall Stiles,** petroleum engineer with U. S. Geological Survey, from Tulsa to Oklahoma City. **Marion J. Moore** was named San An-

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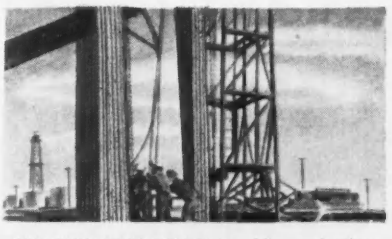

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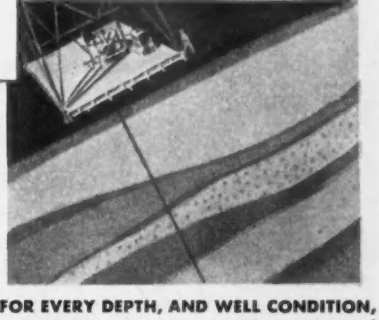

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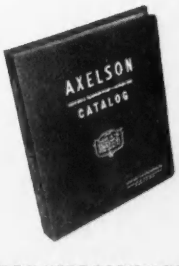

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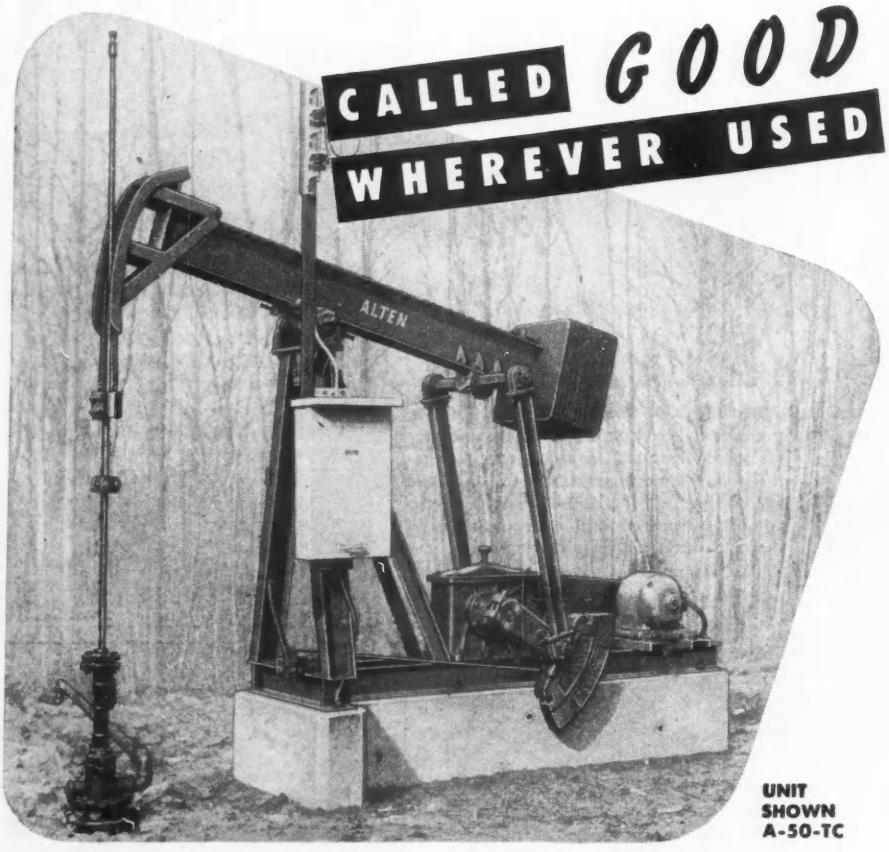
tonio division geologist for Sunray Oil Corporation following the separation of the exploration and land departments. **T. W. Rich** will be scout, **Leroy C. Cockrell,** district landman, and **Homer F. Deen,** landman at San Antonio. **W. R. (Ray) Shively** has been moved to Midland as district landman with **Dewey Gibson** as permit man for West Texas. **E. A. McCullough** will be district geologist at Midland with **John L. Norris** and **Clarence Symes, Jr.,** as geologists. In Wichita, Kansas, **S. A. Shannon** has been named district geologist with **Fred S. Lillibridge** and **R. A. Shelley** as geologists, and **Claude C. Winchell** as district landman.

C. F. Schock, division landman, has been placed in charge of Stanolind Oil & Gas Company's new Canadian division at Calgary, Alberta. Schock was formerly assistant division landman, Central division, Oklahoma City. **A. R. Winzeler** is the new division geologist of the Canadian division and **E. J. Hughes** has been appointed office manager. Winzeler was formerly district geologist at Jackson, Miss. Hughes was formerly an administrative assistant in the accounting department, general office, Tulsa. **R. F. Hodder** has been made district geologist, South Texas district, San Antonio. He was formerly a senior geologist in the Houston division office. **N. S. Whitmore** has been appointed field project engineer in charge of construction of Slaughter natural gasoline plant, Levelland, Texas. He was formerly in the engineering and construction section of the manufacturing department in the Tulsa general office. **C. B. Pierce** has been appointed field project engineer in charge of construction of the natural gasoline plant at Elk Basin, Wyoming. He was formerly in the engineering and construction section of the manufacturing department in the Tulsa general office. **J. C. Johnston** has become district geologist in the Mississippi-Alabama district with headquarters at Jackson, Miss. He was formerly a senior geologist in the Wichita, Kansas, office. **E. H. Garrison** has been appointed district landman for the Panhandle district with headquarters in Amarillo, Texas. He formerly was a landman at Tyler, Texas. **W. E. Phillips** has been appointed party chief of a seismograph crew at Hobbs, N. M. **W. C. Wagner** has been appointed a party chief of a seismograph crew at San Angelo, Texas.

ALTEN UNIT PUMPERS



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J. C. Denney, former Civil Engineer of the North Government Wells district, Southwest Texas division, Humble Oil & Refining Company, is now district civil engineer. **L. H. Byrd,** district petroleum engineer at Hawkins, East Texas division, was promoted to assistant district superintendent of the London district. **W. B. Ewing** and **C. N. Hunt** have been transferred from the London district, East Texas division. Ewing has been promoted from assistant district superintendent to district superintendent at Pruitt. Hunt, former farm boss, is now assistant district superintendent of the Wink district, West Texas division. **C. E. Stanley,** district superintendent, has been transferred from the Pruitt district, East Texas division, to the Thompsons district, Gulf Coast division. **H. W. Roberson,** formerly district superintendent of the Navarro Crossing district, East Texas division, is now in the same capacity with a Gulf Coast division district to be announced later. **C. M. Boatman** has been promoted from farm boss, McCamey district, to assistant district superintendent in the Hobbs district, West Texas division. Also promoted to assistant district superintendent, **C. C. McNeil,** former farm boss in the Wink district, is now at the Wasson district, West Texas division. P. M. McFadden, assistant district superintendent, formerly of the Hobbs district, is now in the McCamey district, West Texas division.

Charles E. Wilson has been promoted from division superintendent of Stanolind Pipe Line Company's West Texas area to area superintendent of West Texas and New Mexico, with headquarters at Brownfield, Texas; **G. L. Miller,** promoted from district foreman, Fort Worth, to area master mechanic of the East and Central Texas area, with headquarters at Fort Worth; **O. C. Watson,** promoted from assistant master mechanic, Tulsa, to area master mechanic of the Missouri and Illinois area, with headquarters at Carrollton, Mo.; **C. E. Schuyler,** promoted from division

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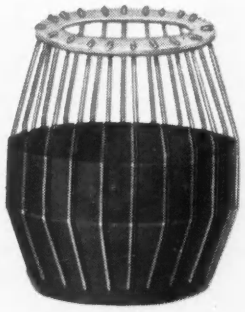
The Guiberson TYPE "K" SWAB with TWO TYPES of CUPS

Field men have never hesitated to acclaim the Guiberson Type "K" Swab the best in the industry—and now it is offered with *two distinct types of cups,* to do more jobs for you and do them *better.*



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machinist of Southern Oklahoma division to area master mechanic of the Oklahoma area, with headquarters at Shawnee; **J. P. Bradley,** promoted from division gauger, Fort Worth, to district foreman of Bowie district, with headquarters at Bowie, Texas; **Irvin M. Barnett,** promoted from chief station engineer, Carrollton, Mo., to district foreman of the Humboldt district, with headquarters at Humboldt, Kansas; **I. H. McVicker,** division superintendent headquartered at Bowie, Texas, will have his territory extended to include main lines and stations in the Central and East Texas area south to Mexia station, Mexia, Texas; **J. J. Dougherty,** Division Superintendent, headquartered at Tomball, Texas, will have his territory extended to include main lines and stations in the Central and East Texas area north to include Mexia station.

»

L. J. Fulton has been appointed assistant to the manager in charge of exploration in the Rocky Mountain producing division of The Pure Oil Company. **K. Stewart Cronin** was named chief geologist of the division, and **Robert A. Fellows** was appointed division development geologist. Fulton, who has been chief geologist of the Rocky Mountain producing division, joined Pure's geological staff at Tulsa in 1930. He subsequently served in West Virginia, Illinois, North Dakota, Colorado and, since 1943, at Billings, Mont. Cronin joined Pure at Houston in 1933 and has since served in the Southwestern division at Tulsa, the Illinois division at Olney, and in the Rocky Mountain producing division since 1945. Fellows joined Pure's geological staff in the Illinois division in 1937. He was transferred to the Rocky Mountain producing division in 1943 and has since been engaged in the Denver office and at Billings.

»

J. S. Baker, Shell Oil Company geologist, Midland to Houston; **W. M. Cogen,** geologist, Houston to San Antonio; **R. R. Eckart,** junior exploitation engineer, Houston to Quitman; **J. M. Fillman,** exploitation engineer, Tulsa to Houston; **J. M. Fouts, Jr.,** senior exploitation engineer, Kilgore to Houston; **H. M. Goodman,** senior geologist, Midland to Houston; **S. Johnston,** geologist, Midland to Houston; **D. E. Jones,** exploitation engineer, Kilgore to Premont; **E. H. Leeman,** exploitation engineer, Tulsa to Houston; **N. Rackley,** draftsman, New Orleans to Houston; **S. B. Schaeffer,** geologist, Midland to Houston; **W. K. Smith,** exploitation engineer, Quitman to Kilgore.

»

Simeon B. Christy and **L. W. Storm** head the new land and geological offices established by Sun Oil Company at Denver as headquarters for an exploration program in the Rocky Mountain area. Christy joined Sun's Production department in 1919. After serving as chief civil engineer in the Beaumont office, he was engaged in leasing and scouting activities in West Texas and from 1930 to 1932 served with Susquehanna Pipe Line Company. He was transferred to the Marketing department in 1932 and returned to the Production department in 1946. Storm joined Sun in 1925 and ten years later joined Schlumberger Well Surveying Corporation. During the war years he was with the U. S. Board of Economic Warfare. He returned to Sun's Production department at Dallas shortly before the end of the war.

»

E. J. Montgomery and **R. M. McGowen** of Stanolind Oil & Gas Company's Accounting department, have received promotions. Montgomery was named chief accountant in charge of general accounting, producing, manufacturing and exploration accounting as well as oil and gas settlements. McGowen, who previously was section head of the tax section, has been made tax accountant and will be in charge of the section. Both are in the Tulsa office.

»

Paul Bagley has been promoted to sales and transportation manager for Lone Star Gas Company, succeeding **Albert F. Garrett,** who has retired.

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Here's a driller that's on the spot with the right equipment to do a bang up drilling job. With the Martin-Decker "SEALTITE" Drilling Control giving him maximum assistance he doesn't have to run all over the rig from gauge to gauge to know what's going on. Every bit of information he needs is centralized right in front of his controls.

The "SEALTITE" Drilling Control offers greater efficiency and convenience because . . . (1) not one—but all five, pretested, loaded and factory sealed, vital control units in one compact steel case, are ready to go to work. Here in this 22" x 14" steel case is a weight indicator with supersensitive vernier mechanism, mud pump gauge, torque gauge, tachometer, and a recorder that charts all variations in weight on bit, mud pump pressure and drill pipe torque; (2) the Martin-Decker "SEALTITE" Drilling Control is mounted at the drawworks directly in front of the driller's position where he can conveniently keep an accurate check on complete underground operations without ever having to leave the instrument.

There's a Martin-Decker Instrument for Every Weight Control Need
Write for Catalog

HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY, T. J. CULLEN, BAKERSFIELD, CALIFORNIA
MID CONTINENT DISTRIBUTOR REED ROLLER BIT COMPANY HOUSTON, TEXAS

This Unibolt flow bean of plain carbon steel was extremely corroded after

45 DAYS

in a Harris County, Texas, well.

This Unibolt flow bean of special chrome alloy steel showed no signs of corrosion after

1 YEAR

in the same gas-condensate well.

CHRISTMAS TREE CORROSION CAN BE STOPPED!

Here is encouraging news in the fight against gas-condensate corrosion. The above pictures graphically illustrate how a UNIBOLT high-chrome alloy steel flow bean was unaffected by exposure for more than a year to the same corrosive condensate that practically ate up a plain carbon steel bean in forty-five days.

UNIBOLT Couplings, Tees, Crosses and Chokes of the same high-chrome alloy, which is given a special heat-treatment involving extremely close control of temperatures to obtain maximum resistance to corrosion, have proved equally superior to ordinary steel fittings.

Operators whose wells are subject to gas-condensate corrosion are invited to write for complete details on UNIBOLT High-Chrome Fittings.

Pictured here is UNIBOLT Flow Mani fold for Christmas Tre service. Each fitting i this assembly can b furnished in high chrome alloy to resis gas-condensate cor rosion.

THORNHILL-CRAVER COMPANY
HOUSTON, TEXAS

UNIBOLT *High Chrome* **FITTINGS**

Roy B. Jones, 65, founder and former president and general manager of the Panhandle Producing and Refining Company, died February 29, at Wichita Falls, Texas. He headed the company 27 years and since retiring in 1943 had devoted his time to private oil properties. Jones moved from Illinois to Cushing, Okla., in 1911 as general manager of Colonial Refining Company, and also operated Jane Oil and Gas Company. During the war years he was a director of PAW. He had acted as chairman of the NRA oil marketing division that prepared the marketing code for the petroleum industry. He was a director of the API and served on a number of its committees.

DEATHS

Harry W. Reade, 56, apparatus sales manager for Air Reduction Sales Company, died at Jersey City, N. J., February 15. Reade was born at Balston Spa, New York, November 26, 1891. He settled in Jersey City 34 years ago, at which time he started his business career with the Davis-Bournonville Company. On the acquisition of this firm by Air Reduction he became assistant manager of the appratus sales division.

why not the BEST IN SWIVELS?

Be Sure IT'S A KING *Be Safe*

KING SWIVELS 53-GA, 32-GA AND 20-GW

THE PRINCIPAL USES OF THESE SWIVELS ARE:

1. **Drilling shallow and medium depth oil wells.**
2. **Drilling water wells.**
3. **Core Drilling and Geophysical Drilling.**
4. **For slim hole drilling.**
5. **Working over oil wells.**
6. **Washing down pipe and tubing.**
7. **Running with inside pipe cutting tools.**
8. **Running with fishing tools.**
9. **As all purpose, lightweight swivels.**

Types 32-GA, 53-GA and 20-GW swivels are alike in general design, but vary somewhat in detail.

These swivels have been field proven by several years of service and have been accepted as leaders in their class. They are in service throughout most of the oil world.

There are no other swivels which are comparable on a basis of capacity in proportion to weight.

Their high capacity in relation to their lightness makes them ideal for use in remote and inaccessible places.

The 53-GA is used for drilling medium depth oil wells; also used extensively on work-over rigs. It is an ideal swivel for slim hole drilling.

The 32-GA is used with large water well rigs and for drilling relatively shallow oil wells. It is also used with long strings of tubing for washing down and similar operations.

The 20-GW swivel is used for drilling shallow and medium depth wells. The 20-GW is the smaller of the three and is used on water wells, core drilling rigs and the heavier types of Geophysical Rigs. It is also suitable for handling tubing in the shallower oil fields.

All materials used in King Swivels are the best and most suitable for their purpose. Lubrication is provided and all connections are to API specifications or to the order of the customer.

Order Through Your Supply Store

EXPORT: R. S. STOKVIS & SONS, INC.
17 Battery Place, New York 4, N. Y.

See 1948 Composite Catalog (Pages 2129 to 2140) for other King Tools.

KING OIL TOOLS

210 TERMINAL STREET PHONE W. 6-8013

HOUSTON 10, TEXAS

Dr. Nelson H. Darton, 82, geologist, died February 28 at Chevy Chase, Md. Dr. Darton was associated with the U. S. Geological Survey from 1886 until he retired in 1936, except for a period from 1910 to 1913, when he was with the U. S. Bureau of Mines. In 1930 Dr. Darton received the Charles P. Daly Medal of the American Geographical Society; in 1940 he was awarded the Penrose Gold Medal from the Geological Society of America; and in 1944 he won the Legion of Honor from the AIME.

Edward F. Moran, 52, Tulsa oil man and drilling contractor, died March 8. He was the brother of **Dan Moran,** recently resigned president of Continental Oil Company. Moran headed E. F. Moran, Inc., drilling contracting concern which he organized in 1920. He was also formerly associated with The Texas Company and Cosden Oil Corporation.

Mackworth H. Davis, 82, pioneer Oklahoma independent oil operator, died February 20, at Tulsa. Davis was born at Queenstown, Penn., and moved to Bartlesville in 1903. He was active in fields in Kansas, Oklahoma, California, West Virginia and Canada, retiring from active business about ten years ago.

John W. Holderman, 59, independent oil operator, died February 20 at Tulsa. A native of Scottsboro, Ala., Holderman went to Tulsa 41 years ago. He had extensive lease holdings and production in Coweta, Okla.

James B. Oakley, 58, production superintendent of the Avant headquarters, Oklahoma, for Shell Oil Company, died February 17 following a heart attack. He had lived in Barnsdall, Okla., for about seven years and had been associated with Shell for 33 years.

William John Brown, 80, pioneer Oklahome drilling contractor, died at Tulsa February 18. He was a native of Butler, Penn., and went to Tulsa in 1907, where he made headquarters while operating in many Oklahoma fields. He retired about 20 years ago.

H. I. (Mickey) Lyvers of Houston was killed March 5 in an automobile accident near Sinton, Texas. Lyvers was connected with Gilger Drilling Company and had been in the oil business 25 years.

John Preston Sutton, 71, for many years an executive of The Ohio Oil Company, died of a heart attack February 24 at Findlay, Ohio. Sutton was connected with Ohio 38 years and at the time of his retirement from active service January 1, 1942, he was industrial relations manager and assistant treasurer.

Fred Day, 32, engineer for Stanolind Oil & Gas Company, was found shot to death, a pistol in his hand, in an automobile near High Island, Texas, March 1.

Povl Ostergaard, chief process engineer of Gulf Oil Corporation, died February 17, at Pittsburgh. He invented and developed the Gulf Polyform Process.

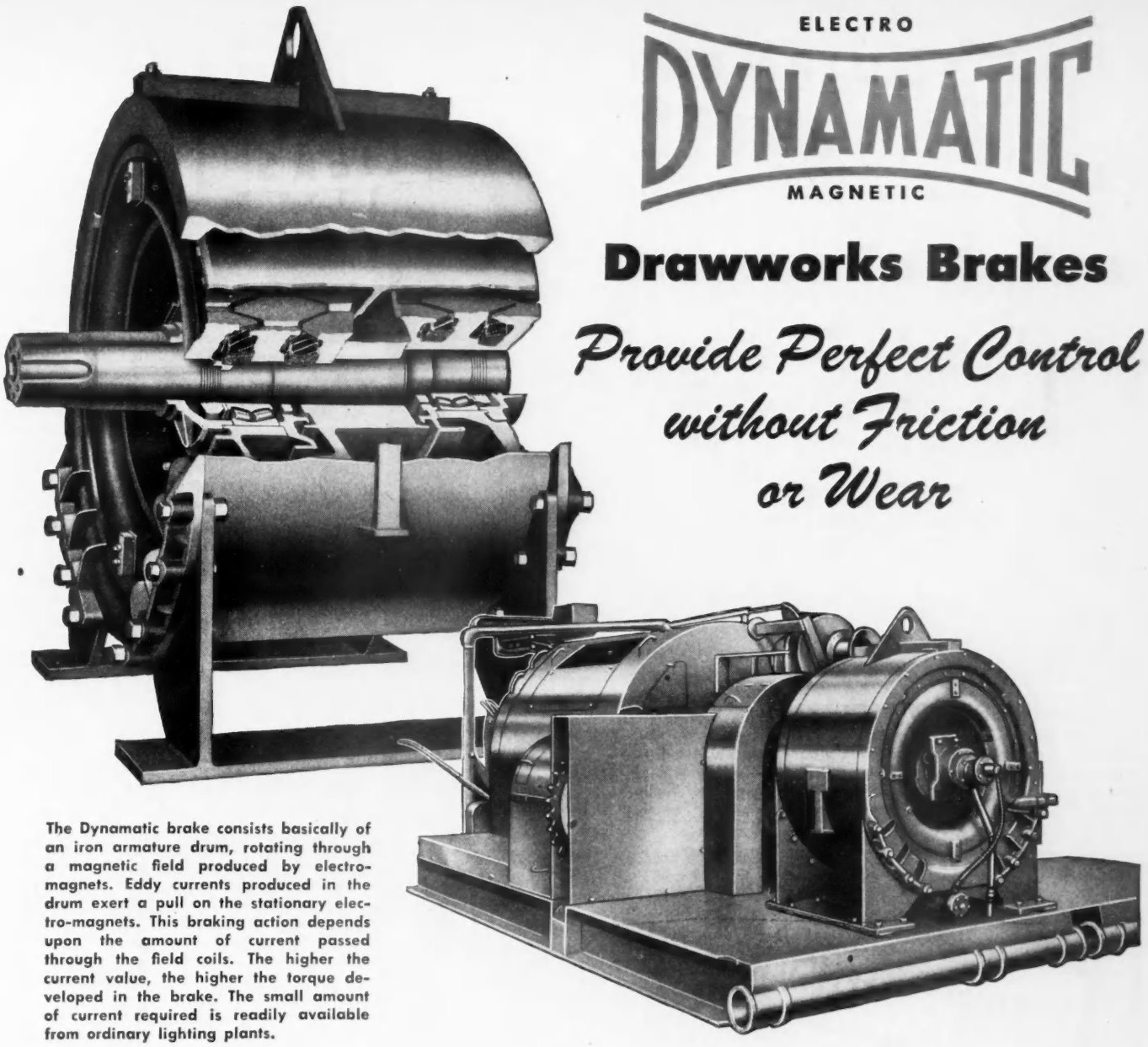
ELECTRO

DYNAMATIC

MAGNETIC

Drawworks Brakes

Provide Perfect Control without Friction or Wear



The Dynamatic brake consists basically of an iron armature drum, rotating through a magnetic field produced by electro-magnets. Eddy currents produced in the drum exert a pull on the stationary electro-magnets. This braking action depends upon the amount of current passed through the field coils. The higher the current value, the higher the torque developed in the brake. The small amount of current required is readily available from ordinary lighting plants.

THE Dynamatic electro-magnetic drawworks brake provides a braking effect which is variable and controllable through a range from 800 rpm to a drum speed slow enough to set slips on the heaviest strings of drill pipe or casing, without the assistance of the friction brake. Mounted similarly to the hydraulic type brake, the Dynamatic drawworks brake is comparable in size and weight. Energy absorbed by the brake is converted into heat, and dissipated in the cooling water. Remote control at the driller's position permits ease and speed of operation.

Outstanding characteristics of the Dynamatic brake are high torque at low speeds, and the complete absence of friction or wear, except on bearings, which have been designed oversize to permit continuous operation for years.

The Dynamatic brake is readily applied to practically all drilling rigs.

Sales Representatives: **GRIBBIN AND BAYLOR** Los Angeles • Houston • Fort Worth

DYNAMATIC **CORPORATION** • KENOSHA, WISCONSIN

Subsidiary of **EATON MANUFACTURING COMPANY** *Cleveland, Ohio*

General Offices: CLEVELAND, OHIO. *Plants:* CLEVELAND • MASSILLON • DETROIT • SAGINAW
BATTLE CREEK • MARSHALL • VASSAR • KENOSHA • WINDSOR (CANADA)

EQUIPMENT AND SERVICE SUPPLIERS' NOTES

MID-CONTINENT GETS CONTRACT—S. R. Billingsley, left, sales engineer for Mid-Continent Supply Company, is congratulated by J. B. Kelly, sales manager of the Fawick Airflex Company, Inc., of Cleveland, on Mid-Continent's recent acquisition of a contract giving exclusive distribution rights of Fawick clutches in all U. S. oil fields. J. E. Everroad, second from left, is general manager of Mid-Continent's diesel, machinery and engineering departments. On the right is J. V. Eakin, district manager for Fawick at Dallas.

SIMPLE • EFFICIENT • DEPENDABLE
Designed by practical men, who know and appreciate the importance of removing shale from drilling mud, the S I W Rotating Mud Screen is the most complete unit of its kind on the market. With only one moving part, the rotating screen, this Mud Screen will give long service. So finely balanced is this mechanism that the power developed by the weight of mud falling from a one inch pipe will rotate the screen, yet the sturdy construction and capacity is sufficient to handle the flow from an eight inch pipe. Other features of the S I W Rotating Mud Screen are Mud By-Pass, sample catcher and chemical mixer, if desired.
Made in three sizes, S I W Rotating Mud Screens give longer service at lower cost. Inquire now.
Sunshine Iron Works
601 W. MURPHY ODESSA, TEXAS PHONE 4374

Transfers, Promotions Announced At Mid-Continent Supply Meeting

Transfers and promotions were announced at Mid-Continent Supply Company's annual sales meeting in Fort Worth.

D. S. Smith, former district manager at Wichita Falls, Texas, has been transferred to head the Dallas district, recently changed to include Dallas, Kilgore and East Texas. N. W. Dail, former store manager at Rangely, Colo., has taken his place at Wichita Falls. The position at Rangely has been filled by M. C. Shaw, formerly at Kilgore.

W. H. Loyd, Jr., former store manager at Refugio, Texas, has been promoted to assistant district manager of the San Antonio district, in charge of Refugio and Falfurrias, Texas. W. W. Schmid of Refugio was named store manager there. H. B. McCullough has been raised from field salesman at Kilgore to store manager. R. B. King has been transferred from Kilgore to Shreveport as city salesman.

Whelan Becomes Vice President Of Worthington Pump, Machinery

Frank J. Whelan was named a vice president of Worthington Pump and Machinery Corporation, with headquarters at Harrison, N. J. He will be in charge of industrial and oil field merchandising and will be responsible for the sale of Worthington products through industrial and automotive dealers, the sale of power-transmission equipment, and sales to other manufacturers of equipment incorporating Worthington products.

Frank J. Whelan

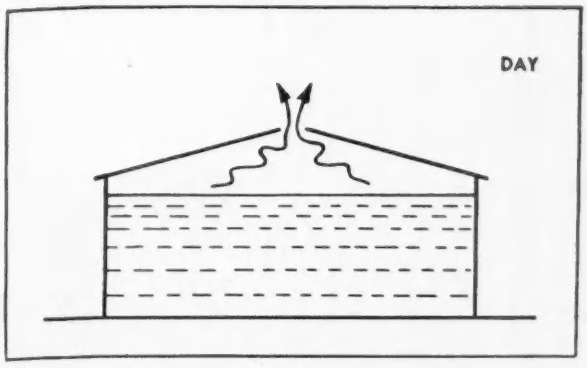
Whelan has been with Worthington for 14 years. Following a year's leave of absence with WPB in Washington he has been, since 1943, assistant to the vice president, as well as manager of the Reciprocating Pump division. He will be succeeded as manager of the Reciprocating pump division by Alvin F. Welsh.

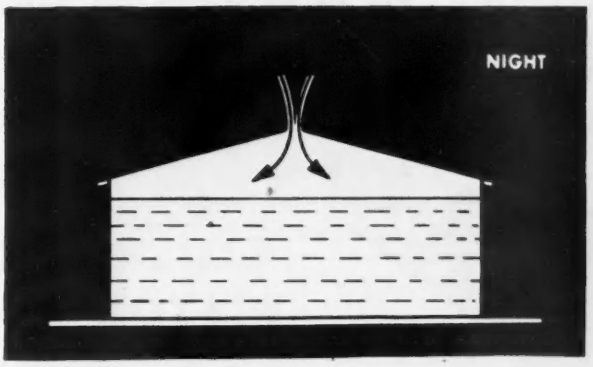
Sales Promotion Manager Named By Air Reduction Sales Company

Dale D. Spoor has been appointed sales promotion manager of Air Reduction Sales Company. Russell S. Schmidt succeeds Spoor as dealer sales manager.

As sales promotion manager Spoor's duties will include the supervision of a sales training program, and, the establishment of sales promotion programs for the various Airco sales districts throughout the country.

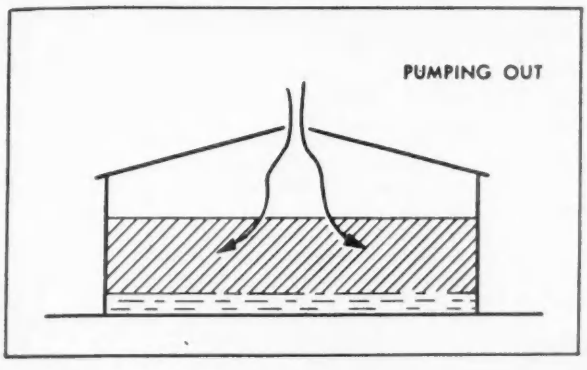
STANDING LOSSES

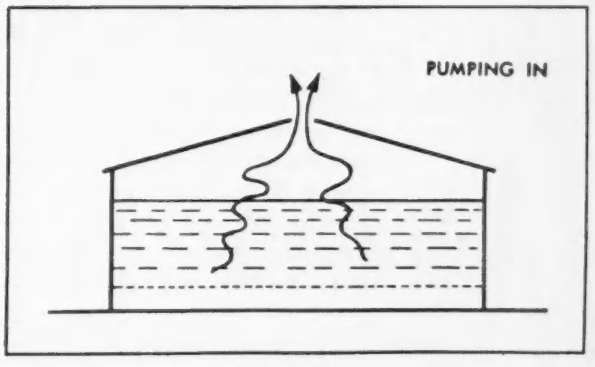




Standing losses vary from 2 to 4 percent of the tank volume per year, depending on the tank size. In addition, the value of the gasoline is reduced through vapor venting.

PUMPING LOSSES





Pumping losses may be conservatively estimated at 0.16 percent of the liquid volume pumped.

THE SOLUTION

The Wiggins Hidek Floating Roof

Hermetically seals the liquid surface.

Permits a relatively small volume of vapor intentionally trapped beneath the roof to expand without venting.

Permits free vertical movement of the roof as it rises and falls with the oil surfaces during filling and emptying.

WIGGINS VAPOR SEALS
GENERAL AMERICAN
*TRADE MARK

General American
TRANSPORTATION CORPORATION

135 SOUTH LA SALLE STREET, CHICAGO 90, ILLINOIS

BRANCH OFFICES: New York • Washington, D. C. • Cleveland • Buffalo • Pittsburgh
St. Louis • New Orleans • Tulsa • Dallas • Houston • Seattle • Los Angeles • San Francisco

SUB-LICENSEES:

WESTERN STATES: Consolidated Steel Corp. — Western Pipe & Steel Co. of California, Los Angeles — San Francisco
SOUTHERN STATES: Wyatt Metal and Boiler Works, Houston — Dallas, Texas
FRANCE: Etablissements Delattre & Frouard reunis, Paris
CANADA: Toronto Iron Works, Ltd., Toronto

WIGGINS HIDEK FLOATING ROOF

WIGGINS BALLOON ROOF

WIGGINS BREATHER ROOF

WIGGINS DRY SEAL LIFTER ROOF

WIGGINS DRY SEAL GAS HOLDER

New INDUCTION HARDENING assures Long Life of FALCON SLUSH PUMP PISTON RODS

Induction hardening up to 700 Brinell — a new electrical hardening process controls heat penetration to give desired depth of hardness with better uniformity and without distortion.

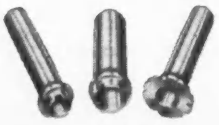
Ordinary case hardening of piston rods causes distortion requiring subsequent straightening and heavy grinding into the hardened surface. Result: irregular hardness subject to more rapid wear.

FALCON Induction hardened rods are made of higher carbon steel alloy with 150,000 psi tensile. After hardening only light grinding is required for a highly polished long wearing surface. Higher tensile steel means greater strength in Rod Tapers and Threads.

Falcon Induction hardened rods are tougher and harder resulting in greater resistance to cutting abrasives and extreme pressures.

OTHER FALCON PRODUCTS

Liners


Swivel Wash Pipes

Interlock Gland Packing

E-Z Out Liner Sleeve

Regular Liner Sleeve

Check Valve

Falcon Products are sold only through leading supply houses everywhere

FALCON PRODUCTS, INC.
POMONA, CALIFORNIA
LOS ANGELES, CALIF. 405 Subway Terminal Building • HOUSTON, TEXAS 1802 Maury Street
Branch Warehouses: ODESSA • WICHITA FALLS • OKLAHOMA CITY • JEANERETTE, LA.
CASPER • RANGELY • BAKERSFIELD, VENTURA & COALINGA, CALIF. • CALGARY, CAN.
Export Representative: Guy E. Daniels, 30 Rockefeller Plaza, New York 20, N. Y.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Brown Oil Tools Makes Addition To Houston City Sales Force

Brown Oil Tools, Inc., Houston, has added Fred W. Dallas, Jr., to its Houston city sales force.

Fred W. Dallas, Jr.

Dallas studied mechanical engineering at Georgia Tech before joining the Army Air Corps in 1939, where he served until 1945, achieving the rank of major.

For 2½ years prior to joining Brown Oil Tools, Inc., he was director of training for Shell Pipe Line Corporation. In addition to his sales activities in Houston, he will make occasional trips for the company into the South Texas and Louisiana areas.

H. K. Porter Names Manager for New Sales Office in Houston

H. K. Porter Company, Inc., Pittsburgh, has appointed William Lee as district manager of its new Houston sales office.

Lee has been associated with the oil industry for 13 years, serving in both sales and service capacity. He will handle the complete line of Porter equipment for the processing and refining industries and will also handle the oil field specialties manufactured by the Hinderliter Tool Company Division of the H. K. Porter Company, Inc., whose plant is located at Tulsa.

The Houston office will be in the Electric Building.

National Supply Representative Aids French in Installing Rigs

C. B. Carter, division engineer, National Supply Export Corporation, New York, took part recently in the French government's extensive new oil exploratory program by assisting with their first installations of drilling rigs. Before his return he also made business visits in several European countries.

Carter is well known in the Gulf Coast and Mid-Continent regions where he was associated with National Supply's stores and also the company's Plant Products division at Houston. He also spent considerable time in the Toledo, Ohio, plant before joining the New York office more than a year ago.

California Service Engineer Appointed by Oil Base, Inc.

Oil Base, Inc., Compton, Cal., makers of Black Magic oil base drilling fluid, announced the appointment of Arch Rater, Jr., as service engineer. Rater will be stationed temporarily in California but later plans to work out of the Oklahoma City office as permanent representative for Oil Base, Inc., in the Mid-Continent.

Rater formerly was with Halliburton Oilwell Cementing Company and Baroid Sales Division. He served with the air corps during the war.

David A. Carnahan Becomes Chief Engineer for Emsco D+B Division

David A. Carnahan was named chief engineer of the D+B Division, Emsco Derrick & Equipment Company. Born on the Shell Oil Company lease at McKittrick, Calif., he won a dergee in engineering from Stanford University and worked in various oil fields. Prior to the war he was affiliated with D+B's Engineering department. During the war he was a lieutenant in the Navy. As chief engineer he will supervise the development and engineering of subsurface equipment at both the Dallas and Los Angeles plants.

David A. Carnahan

Manager of Sales Appointed for Oilwell's Wilson-Snyder Division

Nicholas E. Meyer was named manager of sales for Oil Well Supply Company's Wilson-Snyder division. Meyer, whose headquarters will be at Braddock, Penn., replaces Howard W. Booth, transferred to "Oilwell's" export division.

Meyer has served continuously with Wilson-Snyder since joining Oil Well Supply in 1928.

Atlas Production Acquires B & B Firm's Knife Tool

J. Paul Sievers, president of Atlas Production, Inc., Los Angeles, announced that his firm has acquired the B & B Knife Tool from the B & B Oil Tool Company.

The purchase was made in connection with the policy of acquiring supplemental items to the Hi-Perm offered by the firm's Chemical division, Sievers said.

"Our company has long recognized a need for tools of the capabilities evidenced in the B & B line, which consists of highly specialized tools capable of fulfilling the requirements of any type job, and it is only after complete analysis of well requirements and extensive tests that we have decided to present these perfected tools to the oil industry," the Atlas president declared.

He pointed out further that many production companies have already found the B & B Knife Tool line an answer to their needs and a definite step forward in cleaning plugged-up perforations.

Ashman Becomes Vice President Of Rockwell Manufacturing Firm

J. E. Ashman was elected vice president and controller for Rockwell Manufacturing Company of Pittsburgh. E. W. Meyers is secretary; M. J. Carl, treasurer; and Paul A. Wick and I. C. Rowe, assistant secretaries.

Ashman was affiliated with Burroughs Adding Machine Company and U. S. Steel Corporation before he joined Rockwell as controller in January, 1947. Carl was with Westinghouse Union Battery Company and then spent several years as a certified public accountant before he joined Pittsburgh Equitable Meter Company as assistant auditor in 1929. He progressed through the offices of auditor, controller and assistant secretary-treasurer.

Meyers has been associated with Colonel W. F. Rockwell, chairman of the board of directors of Rockwell, since 1926. Prior to the company's expansion program, when it became necessary to separate the offices, he was secretary-treasurer.

Peerless Opens New York Office For Atlantic District Sales

Opening of a New York office to handle Atlantic district sales of Peerless pumps was announced by F. E. Fairman, Jr., vice president of the Food Machinery Corporation, and general manager of its Peerless division. Sales in this district were previously handled at Ardmore, Penn. The New York office is at 37 Wall Street.

R. C. Engemoen has been appointed district manager in New York.

DAN L. CLARK W. M. AVERILL RUPERT COX

DAN L. CLARK DRILLING COMPANY

Drillers of

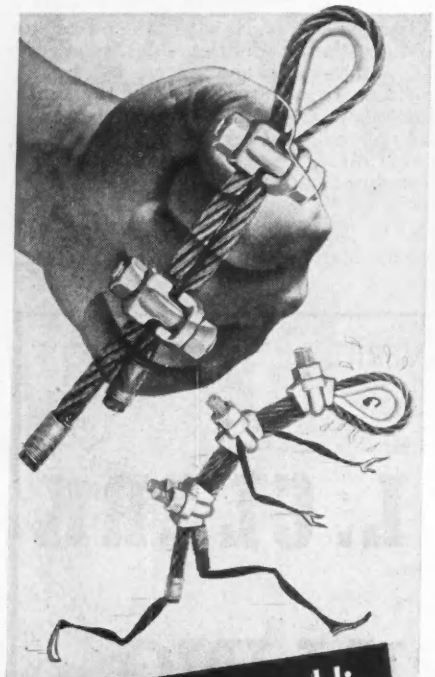
OIL AND GAS WELLS

POWER AND STEAM RIGS

WILSON BUILDING
CORPUS CHRISTI, TEXAS

Telephones
Local 7746—7747 Long Distance 95

BANISH YOUR WIRE ROPE PROBLEMS



...With The Laughlin "FIST-GRIP" SAFETY CLIP

Won't Crimp or Crush... rope lasts longer.

Simple, easy to put on... saves time, manpower.

100% Foolproof... can't go on backwards.

Super Grip... two clips do the work of three U-Bolts.

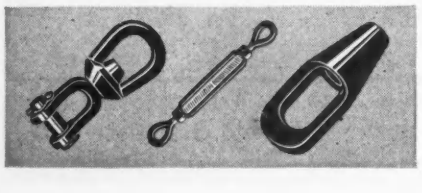
Extra Strength and Safety... clip and bolts drop-forged.

Distributed through mine, mill and oil supply houses. Write for Catalog 140 . . . up-to-the-minute data on industrial fittings.

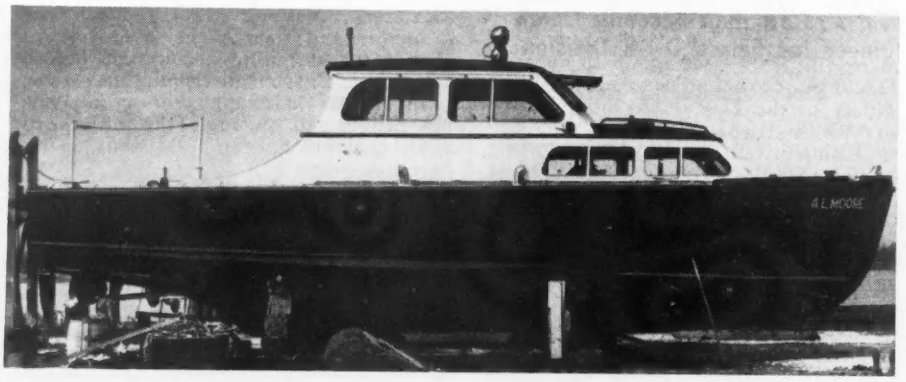
THE THOMAS LAUGHLIN COMPANY
Dept. 23, Portland 6, Maine

LAUGHLIN

THE MOST COMPLETE LINE OF DROP-FORGED WIRE ROPE AND CHAIN FITTINGS



EQUIPMENT and SERVICE SUPPLIERS' NOTES



LAUNCH FOR HUMBLE—Avondale Marine Ways, Inc., has completed for Humble Oil & Refining Company a 40-foot dispatch service launch to be used for transporting personnel in the oil fields in South Louisiana. It is powered by two series 6-71 General Motors diesel engines developing 400 horsepower at full speed. The engines are connected through a 2 to 1 reduction gear to the propellors. It has a passenger carrying capacity of 30 persons. The hull is similar to previous launches built by Avondale for Creole Petroleum Corporation, Standard Vacuum Oil Company and Alcoa Steamship Company.

Pipe Testing Division Manager Appointed by Brown Oil Tools

Ernest L. Potts was named manager of the Pipe Testing division for Brown Oil Tools, Inc., Houston.

Ernest L. Potts

Potts was with Halliburton Oil Well Cementing Company for seven years, five as works manager of the Duncan plant and two as assistant supervisor of mechanical research. Poots also has been chief engineer for Sharp Deflecting Tool Company and Gulf Coast manager for Eastman Oil Well Surveying Company.

As manager of the Pipe Testing division, Potts is in charge of pipe testing operations for Brown Oil Tools. At present two portable hydrostatic testing units are in service for testing pipe, accumulating tanks and other types of pressure vessels on location. One unit is stationed in Oklahoma City serving that district, the other in Odessa serving West Texas. A third unit is under construction for service in the upper Gulf Coast from Houston and a fourth is contemplated for service in Louisiana, to be stationed in Lake Charles.

Standard Brass Named Beaumont Distributor for Parker Appliance

The Standard Brass & Manufacturing Company, Beaumont, Texas, was named distributor for The Parker Appliance Company, Cleveland.

Standard Brass will handle the complete line of Parker tube fittings, valves and accessories for hydraulic and fluid-handling systems. Many parts will be stocked at Beaumont for immediate service to industrial users at the company's Port Arthur, Houston, Shreveport and New Orleans branches, as well.

Howell Named West Coast Sales Engineer for Detroit Diesel

Charles M. Howell has been appointed West Coast petroleum sales engineer for Detroit Diesel Engine division, General Motors Corporation.

Charles M. Howell

He will establish local headquarters in California but operate out of the company's petroleum industry sales office at Tulsa under the direction of Arch F. Campbell.

Howell is well acquainted in California oil field circles, having been associated with the industry in that area for seven of the past ten years. During the war he participated in Mediterranean mine sweeping operations with the Navy and was released from active duty in July, 1946, after attaining the rank of lieutenant commander. He went to Detroit Diesel in January from the Bethlehem Supply Company of California.

John R. Hickman Chosen Head of Goodrich Field Sales Personnel

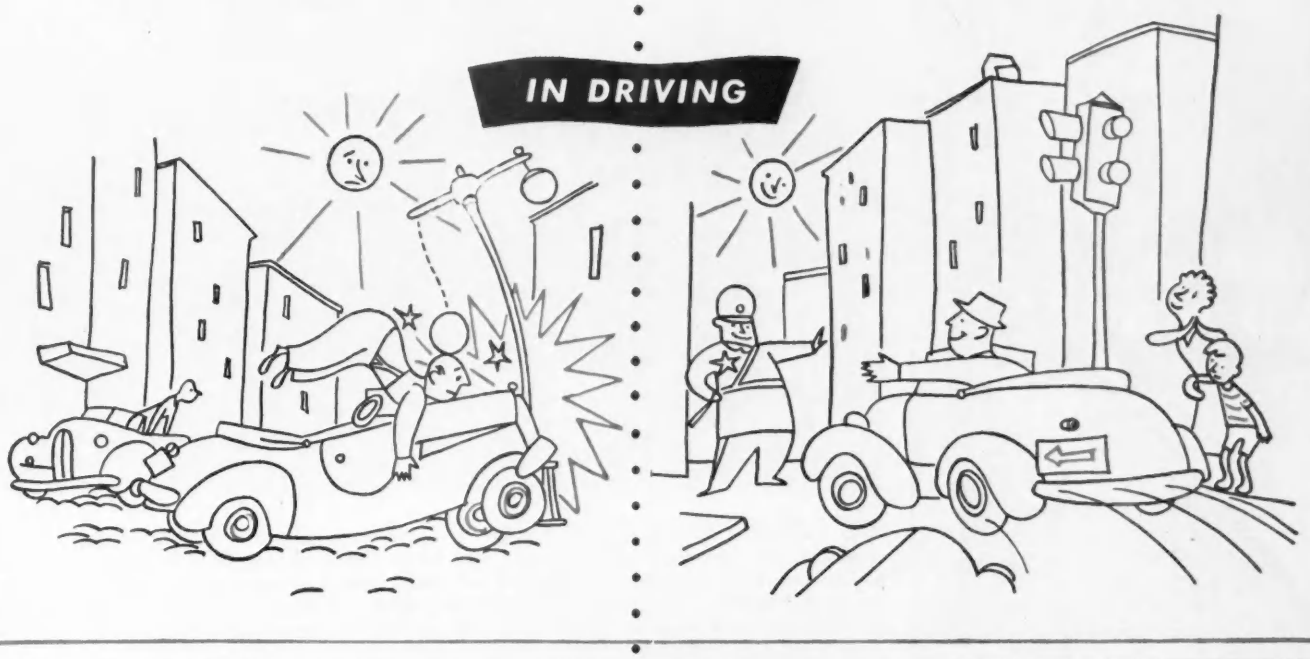
John R. Hickman has been appointed director of field sales personnel of The B. F. Goodrich Company. Hickman succeeds Dale Kramer, who has been granted a temporary leave of absence for reasons of health. Hickman has been with the company since 1944, starting as a job analyst, and later serving as supervisor of office training. He has been manager of employes' services since 1946.

Bethlehem Agent Named

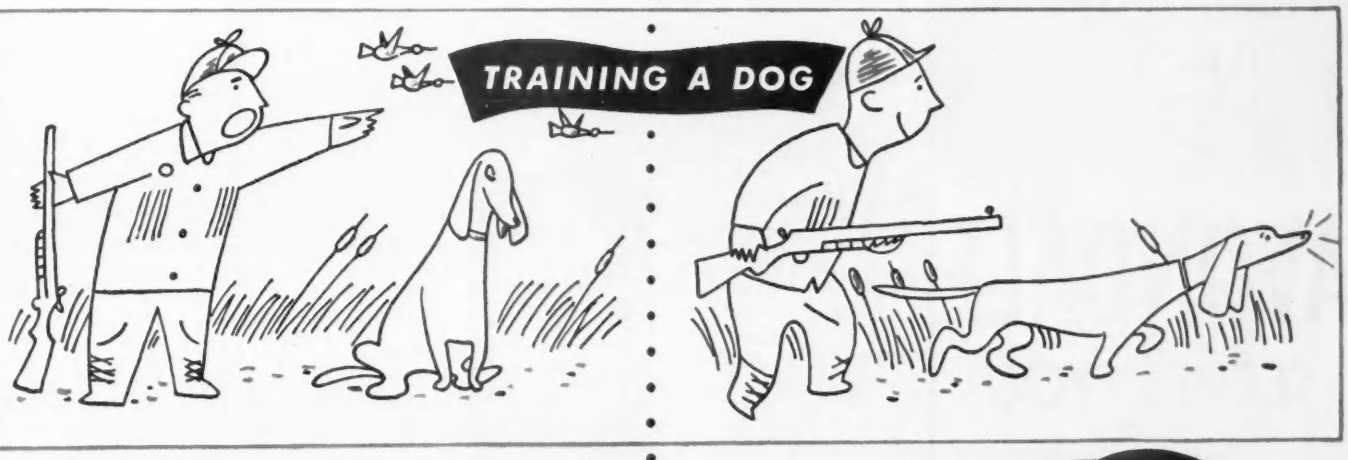
Bethlehem Supply Company has appointed the Petroleum Machinery Corporation, 30 Rockefeller Plaza, New York, as exclusive export agents for Bethlehem Supply Company rotary machinery, hoists and pumping units.

KNOW HOW *makes a difference!*

IN DRIVING

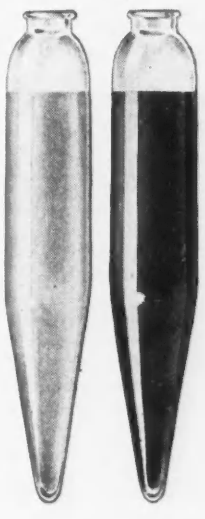


TRAINING A DOG



OR BREAKING AN EMULSION

When it comes to emulsion breaking, "know how" is a big advantage you are sure of with Tretolite. The "know how" acquired in many years of treating service for producers everywhere, plus the "know how" gained by many years of careful manufacturing add up to a dehydration service which is unequalled.

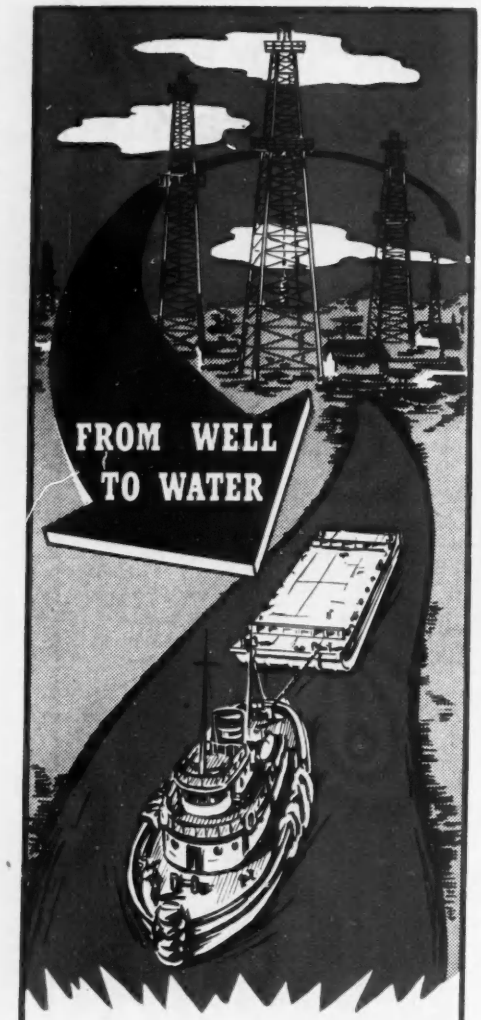


TRETOLITE COMPANY

Manufacturing Chemists

ST. LOUIS 19, MISSOURI • LOS ANGELES 22, CALIFORNIA

DEHYDRATING | DESALTING



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Yes, Avondale serves the Oil Industry in many ways — Tug, Barge, and Towboat building and repair (including propeller work and sandblasting). Call us for your needs.

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Mailing Address: Westwego, Louisiana

RIG FOR DRILLING IN MEXICO—Inspecting equipment for deep exploratory drilling in Mexico which has just been purchased from Franks Manufacturing Corporation by Marshall & Smith, Artesia, N. M., drilling contractors, are Daniel Laso, left, representing Petroleos Mexicanos for whom Marshall & Smith are to do the drilling, Mrs. F. B. Marshall, Leon Smith, and Marshall. The unit is a skid-mounted Franks SAL 5000 drilling rig powered by two D-17000 Caterpillar diesels and equipped with a Franks 96-foot derrick.

J. J. Burris Joins A-1 Bit as Consultant on Keyseat Wiper

J. J. (Joe) Burris has joined A-1 Bit & Tool Company, Houston, as consultant on the Burris Key Seat Wiper, recently acquired by the firm for manufacture, sales and service. Born in Pueblo, Colo., and educated at the U. S. Naval Academy, Burris was with Midwest Refining Company until it was absorbed by Stanolind Oil & Gas Company. Subsequently, he was employed in East Texas as field foreman and as district superintendent of Southwest Texas. After leaving Stanolind in 1945 he perfected the Burris Key Seat Wiper.

J. J. Burris

An outstanding recent application of the instrument has been in the Sugar Valley field, where key seat troubles presented a difficult drilling problem.

Sales-Engineering Conferences Planned by Goodyear in April

Annual sales-engineering conferences of Goodyear Tire & Rubber Company's Mechanical Goods division will be held in April at Lincoln, Neb., and New York City, it was announced by H. D. Foster, manager of the Mechanical Goods division.

A four-day conference, beginning April 6, will be held in Lincoln at the Cornhusker hotel for district sales managers and field representatives in the Western division. One day will be devoted to inspecting production operations at Goodyear's belt plant in Lincoln. The New York meetings are to be held April 21, 22, 23 at the Park Central hotel for salesmen of the Eastern division.

Approximately 150 salesmen will attend the conferences, including 30 executives and department heads from Akron.

Arizona-Nevada Regional Manager Appointed by Kelite Products

Kelite Products, Inc. announced the promotion of Clarence Coleman to the position of regional manager of the Arizona-Nevada district with headquarters at Phoenix.

Coleman joined Kelite in 1943 and was assigned the Southern Arizona-Western New Mexico district making it one of the most active Kelite areas.

Wilmer H. Cordes Named Manager Of American Steel Advertising

Wilmer H. Cordes, manager of the Market Development division of American Steel & Wire Company, has assumed the added duties of manager of the Advertising division of that U. S. Steel subsidiary.

Cordes this year will celebrate his 35th anniversary with American Steel & Wire, having first been employed as a messenger in the mailing department at Chicago in August, 1913. He was appointed manager of advertising in December, 1928, and subsequently held a number of other positions before being named manager of the Market Development division in January, 1947.

Sterling Opens Office

Sterling Electric Motors has opened a Houston district sales office in the M and M Building with Ben H. Schroeder as sales manager.

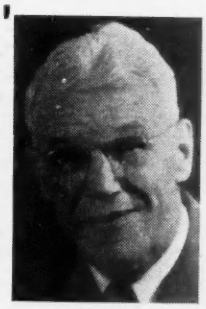
Vice President Named

Engineering Controls, Inc., Los Angeles, has appointed Hans Bohuslav as vice president in charge of engineering.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Paper on New Emsco Mast Wins $2200 Award for Engineer

H. D. Hilborn, chief structural engineer at the Houston plant of Emsco Derrick and Equipment Company, won the Lincoln Award for his paper on the design and construction of the new Emsco 18 P Bulge Type Portable Mast for drilling to depths in excess of 15,000 feet. In competition with entries received from all six continents, Hilborn received the second highest classification award and was presented $2200. The Lincoln Award is made periodically by the Lincoln Electric Company for outstanding achievement in connection with scientific research and development.



H. D. Hilborn

Many outstanding design features are incorporated in the new Emsco 18 P Portable Mast. It is 136 feet high and has a crown block capacity of 800,000 pounds. Base dimensions of 16 feet by 26 feet are sufficient to accommodate the largest draw-works. The 26-foot dimension carries up vertically to the working platform, providing twice the racking capacity of conventional portable masts. As a result of this construction, 192 stands of 4½ inch outside diameter drill pipe may be racked in one bulge, keeping inside stands five feet from the center of the well. For barge workover operations, the 18 P Mast may be equipped with two bulges permitting racking of both drill pipe and tubing simultaneously.

J. F. Simpson Named Vice President Of International Derrick Company

James F. Simpson, for the past four years assistant secretary of Dresser Industries, Inc., Cleveland, has been made vice president of The International Derrick & Equipment Company, a Dresser subsidiary, it was announced by O. M. Havekotte, president of Ideco.

A native Texan and former resident of Dallas, Simpson is a graduate of Southern Methodist University and the Detroit (Michigan) School of Law. He will make Dallas his headquarters, with offices in the Ideco Building.

Link-Belt's Pittsburgh Office Moved in Expansion Program

Link-Belt Company has moved its Pittsburgh district sales office to the former McKay residence at 5020 Centre Avenue, Pittsburgh 13.

This move is the first step in a program designed to expand the company's facilities in western Pennsylvania.

Plans are now being developed for new office and factory-branch store buildings to be erected on the site, to replace the residence, which will, however, meanwhile provide larger quarters than have been available previously.

Today's Foremost POWER VALUE
4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES
★ AIR-COOLED POWER
For their proven ability to deliver maximum performance, year after year, experience-built Briggs & Stratton engines are recognized as today's foremost power value for industrial equipment, farm machinery, and appliances. To make certain your equipment has the utmost in power, stamina, and reliability, specify Briggs & Stratton 4-Cycle air-cooled engines — the RIGHT Power to meet the most exacting requirements.
BRIGGS & STRATTON CORPORATION, Milwaukee 1, Wisconsin, U. S. A.
Attend WISCONSIN CENTENNIAL EXPOSITION Milwaukee August 7-29
WORLD WIDE Factory Supervised Service

U. S. Steel to Begin Operation This Year of Nine New Facilities

Nine of the 12 new major facilities now under construction by U. S. Steel will begin operations this year, according to the U. S. Steel quarterly. These are the principal elements in U. S. Steel's $500 million development propram in which virtually all operations, from the ore and coal mines to the sales offices, will share.

The following approximate dates have been set for the completion of the 12 major projects:

Increase in the cold rolled strip and tin plate productive capacity at the Irvin Works of Carnegie-Illinois, Pittsburgh district, fourth quarter, 1948. Increase in the cold rolled strip and tin plate productive capacity at Gary Works of Carnegie-Illinois, Chicago district, fourth quarter, 1948. Conversion of a hot rolled mill to a cold reduction mill at Fairfield Works of Tennessee Coal, Iron and Railroad Company in the Birmingham district, fourth quarter, 1948. New research laboratory at Duluth and Trout Lake pilot plant at Coleraine, Minn., Oliver Iron Mining Company to improve and beneficiate the lower grade ores of the Mesabi range, second quarter, 1948. New cold rolled strip mill at Pittsburg, Calif., by Columbia Steel Company, now nearing completion, second quarter, 1948. New cold rolled strip mill at Los Angeles, by Columbia Steel Company, fourth quarter, 1949.

Construction program of National Tube Company at Lorain, Ohio, and additional tubemaking facilities at Gary, Indiana, first quarter, 1949. Remodeling of the 132-inch plate mill of Geneva Steel Company, Utah, for the manufacture of hot strip coils to supply west coast mills, first quarter, 1949. New coal washers at Robena Mine, H. C. Frick Coke Company, and Gary, United States Coal and Coke Company, third quarter, 1948. New coke oven battery at Clairton, Pa., works of Carnegie-Illinois Steel Corporation, fourth quarter, 1948. Increased production of silicon steel at Vandergrift, Penn., works of Carnegie-Illinois Steel Corporation, second quarter, 1948. Two new modern blast furnaces at South Works, Carnegie-Illinois, Chicago, second quarter, 1948.

Install Them and Forget Them!
AMERICAN
RADIAL
Roller Bearings
AMERICAN RADIAL ROLLER BEARINGS are engineered to exacting standards that result in better performance and minimum maintenance.
Furnished in 5 styles, 6 S.A.E. series and 85 sizes. Special designs also available. Write.
AMERICAN
ROLLER BEARING CO.
420 Melwood Street Pittsburgh, Pa.
Pacific Coast Office:
1718 S. Flower St., Los Angeles, Calif.

Franks Manufacturing Appoints Oklahoma, Kansas Representative

Earl Kirberger, one of Franks Manufacturing Corporation's 15-year diamond pin men, has been named to handle the Oklahoma and Kansas sales territory for the Tulsa rotary drilling rig and servicing unit manufacturer.

Earl Kirberger

Kirberger started with Franks in its early stages. He has served both in the sales and service departments, and during the war worked in the production department.

Assistant to Lincoln Electric Company's President Is Named

James F. Lincoln, president and general manager of The Lincoln Electric Company, Cleveland, announced the appointment of G. F. Clipsham to assistant to the president.

From 1935 until his recent return to the U. S., Clipsham was president of The Lincoln Electric Company, Welwyn Garden City, Herts, England. He went to England in 1935 to organize that company. He joined The Lincoln Electric Company in Cleveland in 1929 and was active until he went to England as welding engineer in various sections of the country.

On South American Visit

Knight C. Templeton is on an extended visit to the oil fields of Peru, Ecuador, Colombia, Venezuela, Trinidad and Mexico. He is associated with Roland E. Smith, export representative for Abegg & Reinhold Company, Atlas Production, Inc., B & W, Inc., Fullerton Manufacturing Company, Globe Oil Tools Company, and Medearis Oil Well Supply Company. He plans to return to the U. S. in May.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Assistant Advertising Director Chosen by U. S. Steel Corporation

Charles N. Schmidt was named assistant director of advertising, U. S. Steel Corporation of Delaware. Schmidt went to the Delaware Corporation from American Steel and Wire Company, U. S. Steel subsidiary, Cleveland, where he was manager of the advertising division.

Charles N. Schmidt

A graduate of Ohio State University, he served with several newspapers, the United Press and *Steel Magazine* before joining American Steel and Wire in 1938 as advertising production supervisor. He was made assistant advertising manager for the company in 1943 and manager in 1945.

Assistant Divisional Manager of Sales Named by Link-Belt

H. Merrill Bowman, who has been district sales manager of the Link-Belt office at Baltimore, Md., has been appointed assistant divisional sales manager for power transmission equipment, with headquarters at the Pershing Road plant in Chicago.

Eugene S. Bogart was named district sales manager at Baltimore to succeed Bowman. Bogart is being transferred from the Pittsburgh office.

After summer employment at the Link-Belt Philadelphia plant, Bowman became permanently attached to that organization in 1932. The next six years were spent in the Engineering, Sales and Order departments. He was transferred to Baltimore in 1940 as district sales engineer, and became district sales manager in 1945.

Bogart entered the employ of the engineering department of the Link-Belt positive drive division at Philadalphia in 1926. He remained in this department ten years. He was moved to positive drive sales in 1936, and transferred to the company's Boston office in 1937. He was sent to Pittsburgh in 1940, where he first served the positive drive division and later became district sales engineer for both materials handling and power transmission products.

Southern Division Sales Agent Appointed by Hamilton Rubber

Chester W. Mathis, of Dallas has joined the Southern division of Hamilton Rubber Manufacturing Corporation, Houston. Hamilton has established sales offices and branch warehouse stocks in Houston to serve the Southwest area.

Mathis, a native of Oklahoma, has resided in Texas for 19 years. He has been connected with the rubber industry for ten years. His territorial coverage will include Oklahoma, Arkansas, and North Texas.

GET THE FACTS WHEN YOU BUY COMPOUNDS

Men who know the problems of correct lubrication for threads agree that, to provide proper thread protection, compounds must have sufficient "body" to prevent the thread surfaces from coming into contact at maximum pressure. Maximum thread protection is provided by a compound with a low coefficient of friction and maximum fluidity consistent with the body required. It should be non-hardening. It should be free of a tendency to "gum up." It should be free of acid qualities and other corrosive agents. *WECO Thread Compounds meet all these requirements.* That's why WECO is your best thread protection. Get the facts and compare WECO Compounds . . . point by point . . . with any other compound!

WECO Steel-Aid . . . contains 67% pure metallic lead and is made specifically for drill collars and tool joints. Metallic Base WECO Steel-Aid will not squeeze out under high torque pressures encountered in these services.

WECO No-Gall . . . contains more than 50% pure metallic zinc, providing operators with a compound that gives tool joint threads maximum protection. Research and actual use have proved WECO No-Gall affords maximum tool joint efficiency.

WECO Hi-Speed Seal . . . a permanent, non-hardening seal universally accepted for casing and tubing threads, steam lines, and oil and gas lines. Hi-Speed Seal is widely used in butane, propane, gasoline and other petroleum services. Unaffected by temperatures to 600° F.

WELL EQUIPMENT MFG. CORP.
Subsidiary of Chiksan Company
Houston 1, Texas
Exclusive Sales Representative Outside Mid-Continent Area
CHIKSAN COMPANY
Brea, Calif. New York 7
Export Sales: CHIKSAN EXPORT COMPANY, Brea, Calif. New York 7

WECO
Manufacturers and Distributors of Oilfield, Refining, Marine and Industrial Equipment

Hanson-Whitney Machine Company And Whitney Chain Consolidate

Consolidation of The Whitney Chain & Manufacturing Company, and The Hanson-Whitney Machine Company, into Whitney-Hanson Industries, Inc., was announced by Winthrop H. Whitney, chairman of the board of the new company.

The action brings together two of Hartford's leading industries, each of which will operate as a separate division of the new corporation.

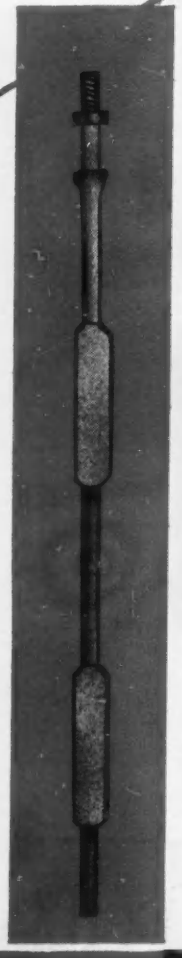
In addition to serving as chairman of the new board, Whitney will be general manager of the Whitney Chain division, while Einar A. Hanson, who has been president of Hanson-Whitney Chain division, will be president of the new corporation. The general manager of the Hanson-Whitney division will be Leon B. Reed, who also will be executive vice president of Whitney-Hanson Industries. Other officers of the new corporation will be Park C. Boyd, secretary; Gordon F. Gilmore, treasurer; and Harry C. Darling, assistant treasurer.

Besides Whitney, Hanson and Reed, the new board of directors will include Roger Gay, president of Bristol Brass Corporation; Robert E. Carroll, vice president of Arrow, Hart & Hegeman Electric Company; Wilbur G. Stauble, executive vice president and secretary of the Holo-Krome Screw Corporation; Milton H. Glover, vice president of the Hartford National Bank and Trust Company, and Thomas Hewes, senior member of the law firm of Hewes and Awalt, counsel for the new corporation.

Whitney Chain was founded in 1896 by the late Clarence E. Whitney, whose father, Amos Whitney, was a stockholder and whose son, Winthrop H. Whitney, has been president since 1938 and now is chairman of the new board. Its main plant and offices are at 237 Hamilton Street.

Hanson-Whitney was established in 1919 by the late B. M. W. Hanson and Clarence E. Whitney. Einar A. Hanson, son of the cofounder, has been its president since 1925 and now is president of the merged companies. Its plants and offices are at 169 Bartholomew Avenue.

Look AT THE SAVINGS YOU MAKE with HUBER PARAFFIN SCRAPERS



	WELL No. 1 Year Before Install.	WELL No. 1 Year After Install.	WELL No. 2 Year Before Install.	WELL No. 2 Year After Install.
Paraffin Expense	$1347.00	—0—	$ 767	—0—
Bbls. Oil Prod.	9859	9046	9978	8502
Paraffin Cost per, Bbl.	$ .137	—0—	$ .077	—0—
Expense Reduction	$1347		$ 767	
First Yr's Operation Installation Cost	401		401	
NET SAVING	$ 946		$ 366	

ROTATING HEAD

This patented head automatically rotates the rod string a fraction of a turn on each reciprocation, so that the scrapers, which clear the tubing by a fraction of an inch, wipe the wall free of paraffin.

Here are the savings a major company made in one year with Huber Scrapers in two of their pumping wells. Well No. 1 saved more than twice the cost of the scrapers. Well No. 2 saved about 90% of their cost. Huber scrapers completely eliminated all paraffin removal expense.

It will pay you to install Huber Scrapers in your pumping wells where paraffin is accumulating. Install them now and end this costly paraffin trouble.

HUBER PARAFFIN SCRAPERS

J. M. HUBER CORPORATION

BOX 831 BORGER, TEXAS

Foreign Accounts Representative Named by General Motors Unit

Edmund Burke, Jr., petroleum and chemical engineer, has joined General Motors Overseas Operations and will be responsible for the sale of General Motors Series 71 Diesel oil field engines to foreign accounts in the New York area.

Edmund Burke, Jr.

Burke graduated from the University of Alabama in 1933. After spending six years in various fields of the petroleum industry, he established his own petroleum sales engineering business in Chicago and later moved his office to New York. He entered the Army Air Corps in 1941. After release from active duty in November, 1945, with the rank of major, he re-entered his own business in New York, where he remained until joining General Motors.

Fairbanks-Morse Announces Factory Management Changes

Fairbanks-Morse & Co., Chicago, announced the following changes in factory management organization.

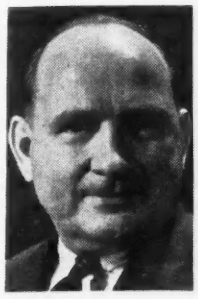
W. H. Holbert, who for the past 20 years has been manager of the company's Stuttgart, Ark., works, has been appointed manager of the Three Rivers, Mich., plant, succeeding Karl E. Barrett, who has resigned because of ill health.

J. R. Walsh, who has for several years been assistant manager of the Fairbanks-Morse Westco Works in St. Louis, has been transferred to Stuttgart, and appointed works manager.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Fred E. Ruebelmann Named General Sales Manager for Penberthy

Since Penberthy Injector Company became a subsidiary of the Buffalo Bolt Company, the products, policies and personnel have continued unchanged with one important exception. Fred E. Ruebelmann was appointed general sales manager to succeed A. D. Thomas, resigned. Ruebelmann has been a member of the Penberthy organization for more than 36 years, most recently as supervisor of sales.



Fred E. Ruebelmann

New Firm to Distribute Leschen Wire Rope Line in California

The A. Leschen & Sons Rope Company, St. Louis, announced that effective April 1 its entire line of oil field wire ropes will be distributed in California by the new firm of Ball and Black Supply Company, 2439 Hunter Street, Los Angeles.

This firm is composed of two experienced wire rope men, C. R. (Chuck) Ball and C. H. (Clif) Black. Ball has been identified with the California oil fields for about 20 years, while Black has been active in the California fields for 25 years, and prior to that he spent a good many years in the Mid-Continent field.

Leschen & Sons have recently established a warehouse at 2439 Hunter Street, Los Angeles.

Twin Disc Clutch Company Opens Branch Office at Los Angeles

The Twin Disc Clutch Company, Racine, Wis., manufacturers of clutches and hydraulic drives, has opened a branch sales engineering office at Los Angeles. The office is in a new building at 2950 Leonis Boulevard, and serves a territory including California, Arizona and Nevada.

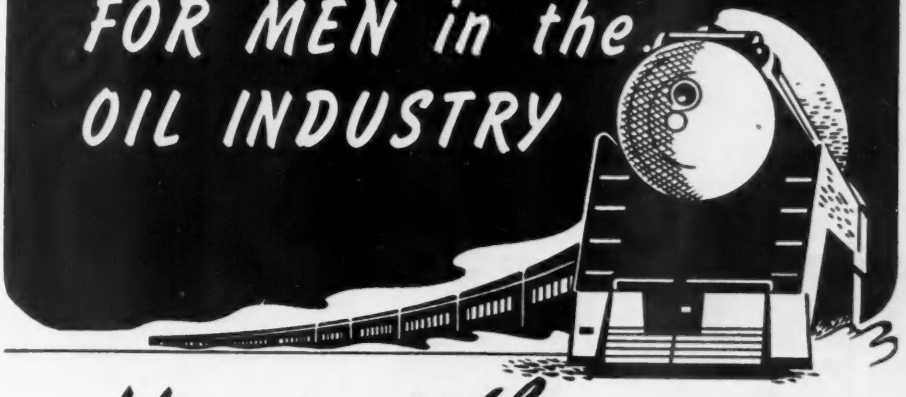
Opening the Los Angeles office brings the number of such branch engineering offices maintained by the Twin Disc Clutch Company to eight.

All Twin Disc activities on the West Coast are under the general supervision of A. E. (Duke) Young, district manager. Sales functions of the California territory are under the direct supervision of Pierce Tyrrell, assistant west coast district manager. Tyrrell previously was associated with the Twin Disc Hydraulic Division, Rockford, Ill., in a sales and engineering capacity.

Preston Olney, formerly field service engineer at the Dallas branch engineering office of Twin Disc, is manager of the Los Angeles office. Olney joined Twin Disc at Dallas in 1939. In 1941, he helped to establish a Twin Disc office in St. Louis, Mo., and two years later was transferred to the Twin Disc Hydraulic Division, Rockford, Ill., as an installation engineer. He returned to the Dallas office in 1946.

Streamlined Sunbeam

MADE TO ORDER FOR MEN in the OIL INDUSTRY



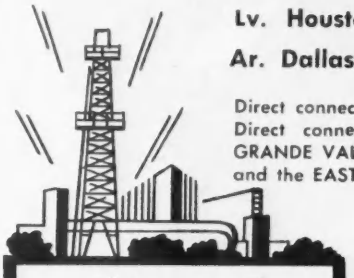
Here's Why —

The **Streamlined Sunbeam** operates on a fast daily schedule between Houston and Dallas, two of Texas' most active oil centers. You may leave either terminal at the close of the business day, enjoy a restful, relaxing ride in smooth comfort, and arrive your destination in mid-evening. The **Streamlined Sunbeam** features Southern Pacific's famed "Meals Select" . . . delicious and well-deserving of their popularity. Whether you ride in low-cost reclining chair car seats, or reserved parlor car space, you'll find the **Streamlined Sunbeam** tops in travel comfort.

265 MILES - 265 MINUTES between HOUSTON — DALLAS

Lv. Houston 4:45 P.M. Lv. Dallas . . . 5:00 P.M.
Ar. Dallas . . . 9:10 P.M. Ar. Houston 9:25 P.M.

Direct connections in Dallas for TULSA and OKLAHOMA CITY. Direct connections in Houston for CORPUS CHRISTI, RIO GRANDE VALLEY, BEAUMONT, LAKE CHARLES, NEW ORLEANS and the EAST.



Attend the INTERNATIONAL PETROLEUM EXPOSITION TULSA MAY 15—22

TWO OTHER FINE TRAINS daily between HOUSTON and DALLAS

STREAMLINED HUSTLER
(MORNING STREAMLINER)
Intermediate Stops

OVERNIGHT OWL
Late evening departure
Early morning arrival

S·P The Friendly Southern Pacific

Cardwell Names Sales and Service Representative for California

With appointment of Leo S. Case, Long Beach, as California sales representative, Cardwell Manufacturing Company, Inc., announced a change in method of representation in California for sales and service parts stocks.

Until recently the oil field equipment manufacturing concern was represented in California through a dealership, but under the new program, the direct representative plan will be used.

Associated with Cardwell since last November, Leo Case was formerly sales engineer for Buda Engine Sales and Service Company in Tulsa for five years.

Case has been in the oil business since 1933, when he went to work for Cities Service Oil Company in Tulsa. He was shortly transferred to Chicago as junior salesman; and while with Cities Service there he attended night school at Northwestern University.

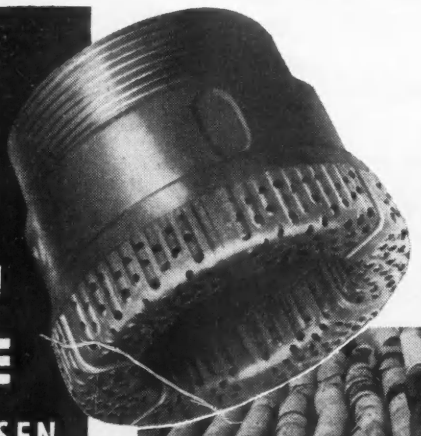
Leaving Cities Service in 1937, he joined Frick-Reid Supply Corporation (now known as Jones & Laughlin Supply Company) at Oklahoma City. Transferred to southern Illinois, he spent five years with the concern before going to work for Buda Engine Sales and Service Company.

Leo Case's address is 3504 Atlantic Avenue, Long Beach; mailing address is P. O. Box 7006, Bixby Station, and his phone number is Long Beach 4-7996.

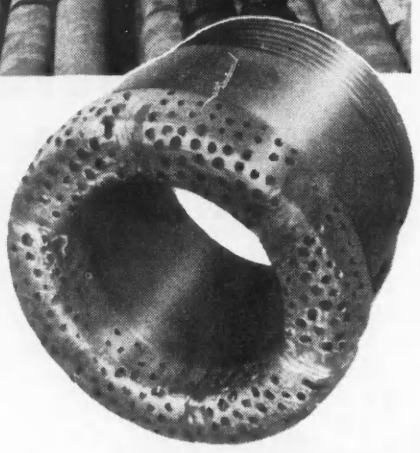
Besides Case's representation in the Cardwell program, Apex Equipment Company of Long Beach and Bakersfield will handle complete stocks of Cardwell parts, company officials said.

The Long Beach address is Apex Equipment Company, 3504 Atlantic Avenue, and phone number is Long Beach 4-7996. The Bakersfield address is Rosedale Highway, P. O. Box 1733. Phone number is 3-4186, and the night number is 8-8370.

1775 FEET WITH ONE CHRISTENSEN DIAMOND CORING HEAD !



This Christensen type C-6-C coring head returned 30 per cent usable diamonds at the end of its remarkable 1775-foot record in the Rangely Field.



● Coring Head P-532-3, part of the core taken and —— the coring head as it looked after its record performance drilling the pay sections in three wells in the Rangely, Colorado, field.

It's "Less-Cost-Per-Foot" drilling like this that saves time and money in the field.

LESS COST PER FOOT CHRISTENSEN DIAMOND PRODUCTS

CHRISTENSEN DIAMOND PRODUCTS CO.

1975 SOUTH SECOND WEST • SALT LAKE CITY, UTAH

TELEPHONE 6-8738

Houston Representative Named By Well Equipment Corporation

John Gates, former assistant day shift shop foreman at Well Equipment Manufacturing Corporation, Houston, has completed the WECO sales training program and has been named a sales representative in the Houston area.

John Gates

Gates has been with WECO more than two years. He formerly was employed by Houston Slush Pump Company and Mission Manufacturing Company. His sales territory will include Houston and the Southern Gulf Coast area.

G. A. Burns Becomes Assistant General Sales Head for Butler

G. A. Burns, manager of the Butler Manufacturing Company's Oil Equipment division, was named assistant general sales manager. He is also a vice president of the firm.

Burns started with the Butler company as a cost clerk in 1913. The following year he was made a salesman. During World War I, he was a sergeant in the infantry. In 1919, he returned to his job as salesman in Minneapolis. In 1936, he became sales manager, Minneapolis Oil Equipment division. He was summoned to Kansas City in 1937 to become manager of the Oil Equipment and Steel Buildings division.

While serving in that capacity, he was sent to Washington where he supervised the opening of a Washington sales branch. He continued doing governmental contract work until December, 1941, when he returned to Kansas City.

He became manager of the Oil Equipment and Special Products division in 1942 when the Steel Buildings division was separated from Oil Equipment. For the past three years he has been manager of the Oil Equipment division. Last year he was made a vice president.

Union Carbide Director Named

Fred H. Haggerson, President of Union Carbide and Carbon Corporation, announced the election of William J. Priestly as a director of the corporation. Priestly has been with the organization since 1923, and has been a vice president in charge of the Alloys and Metals division since 1945.

Harold E. Cooper Becomes Head Of Fred E. Cooper Company

Harold E. Cooper has been elected president of Fred E. Cooper, Inc., Tulsa, succeeding his uncle, Fred E. Cooper, who died in an airplane accident February 6. Before his election he was vice president and director of the company.

Harold E. Cooper

The board of directors elected J. W. Allen to the board and as a vice president. He will continue as manager of manufacturing. Howard B. Appleton was named secretary-treasurer, and H. B. Bloxom was named sales manager. Fred E. Cooper, Inc., has general offices and manufacturing plant at Tulsa, with branch offices at Los Angeles and Lynnewood, Calif., and Houston.

Butler Manufacturing Obtains Factory Building on West Coast

Butler Manufacturing Company of Kansas City, Mo., has purchased a factory building at Richmond, Calif., better to serve customers on the Pacific Coast.

The main factory building is one story, 400 by 413 feet, 70 feet high, and with annexed buildings, covers 179,000 square feet of floor space.

The new Butler factory was built by Kaiser Industries in 1944 and is part of the large shipbuilding yards in Richmond.

Oscar D. Nelson, president and general manager of Butler, said the operation will soon represent an investment of $500,000 or more and that steel buildings will be the first Butler product to be manufactured.

The Richmond division manager will be Paul M. Shoemaker, at present assistant to the Galesburg division manager. Other executives who will be transferred to Richmond to manage and direct initial operations are R. G. Burge, Richmond factory superintendent, who is now the Kansas City factory superintendent; Charles R. Crain, Richmond factory personnel manager, who has that position now at the Kansas City plant; and Lloyd A. Anderson, Richmond steel buildings sales manager, who at present is steel buildings sales manager at the company's Minneapolis plant.

Lightbourn Equipment Appointed Hercules Motor Distributor

Lightbourn Equipment Company, 511 South Industrial Boulevard, Dallas, has been appointed a distributor for Hercules Motors Corporation, Canton, Ohio.

W. S. Lightbourn is the owner of Lightbourn Equipment Company, formerly located in the Santa Fe Building. The move to the new offices and warehouse provides an additional 1800 square feet of space. Lightbourn has been engaged in the oil field and industrial machinery business since 1934. A graduate of Georgia Tech in mechanical engineering, he was previously employed by the Waukesha Sales & Service Company and at the time of his resignation to form his own company was vice president and sales manager for Texas and Louisiana.

R. F. Park, also formerly associated with the same company as district sales manager, is an associate in the Lightbourn Equipment Company. R. W. Whitman, L.S.U. graduate and a veteran, is in charge of the warehouse.

District Manager for Canada Named by National Supply

Alvin B. Geddes, sales representative in the Calgary, Alberta, area, has been appointed district manager in Canada for The National Supply Company, Ltd., with district headquarters at Calgary.

A native of Canada, Geddes was associated with Canadian Westinghouse, Ltd., in the Hamilton, Ont., plant and at Edmonton, Alberta, and later was transferred to Calgary, where he followed sales and engineering work. He joined National Supply in 1943.

PROOF OF BIT EFFICIENCY
(NO. 2 OF A SERIES)

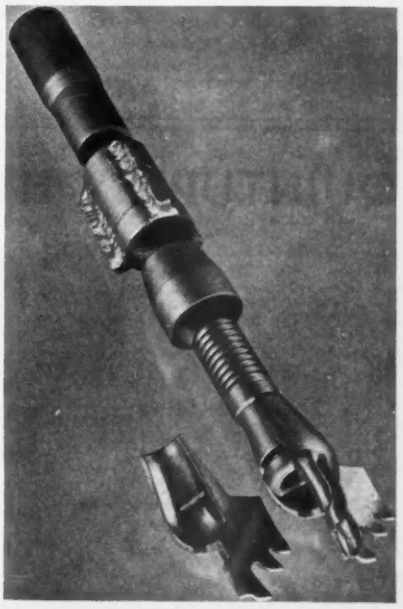
BIT COSTS REDUCED 50%!

After switching to Hawthorne "Rock Cutter" Bits, major seismograph operator's bit service costs were reduced from $695.00 to $373.40 per month per drill . . . "bit costs per foot of hole drilled" dropped from $.1655 to $.0677 . . . same formations . . . same drills . . . same drillers!

That's just one of many savings effected by Hawthorne "Rock Cutter" Bits during a six month's drilling period in which accurate records of bit performance and service costs were kept. Prior to using "Rock Cutter" Bits, this operator was using an average of sixty conventional drag bits and five roller bits per month on each of two drills operating in the same area. After switching to "Rock Cutters," each drill used an average of *two* roller bits and only twelve sets of replaceable "Rock Cutter" blades each month.

Even more remarkable was the increased footage obtained from each drill after "Rock Cutter" Bits were placed in service . . . *average monthly footage per drill rose from 4200 feet to 5600 feet,* or an increase of 33⅓% in the total number of holes completed each month!

"Rock Cutter" Bits can bring the same economies to *your* operations. Why not order a bit assembly and stock of blades today . . . they're available for immediate delivery, in all popular sizes for all types of drill rod. Complete details will be furnished upon request.



Hawthorne Replaceable Blade Bits are easily serviced on the drill, with tools commonly available. When assembled, the bit is a completely rigid unit that cannot loosen or "chatter" during drilling operations.

Herb J. Hawthorne
INC.
Offices: 2001 Harold HOUSTON 8, TEXAS P. O. Box 7299

WORLD OIL'S Trading Post

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Rates: Regular Classified (undisplayed) set in this size type: 10 cents per word. If Box Number is to be used count an additional six words. Replies forwarded without charge. Situation Wanted: 5 cents per word. Display advertisements, set in suitably larger type with ruled border: $9.00 per column inch per insertion. Situation Wanted: $4.50 per column inch. **All classified ads payable in advance.** 10% Discount if 3 or more insertions are ordered at one time. **COPY DEADLINE:** 10th of month preceding date of issue. Send copy and checks to: Trading Post Section, World Oil, P. O. Box 2608, Houston, Texas.

FOR SALE

■ For Sale—American Association Petroleum Geologist Bulletins previous to 1935. 224 E. Hillcrest Blvd., Monrovia, Calif.

■ For Sale—Oil and Gas Leases on 11,000 acres fee land in sensational Powder River Basin of Wyoming. R. G. Park, 539 Downing, Denver 3, Colo.

FOR SALE

■ For Sale: Model M-Allis Chalmers double drum skid type unit with spudder attached, mounted on a 3½ ton White truck. Both units are in first class condition. Write to David Shafer, Wooster, Ohio.

For Offshore Operations

FOUR (4) L.S.T.'s

For immediate conversion to purchasers requirements and specifications.

✶

PORT CITY IRON WORKS, INC.

7200 South Harbor Drive
Phone: W 6-9601
Houston, Texas

For Sale

1—SA4500 Franks Skid Type Rotary Rig Complete with

1—FXZ 7¼ x 12 Gardner Denver Pump New Liners—A-1 Condition

2—HS600 Cummins 200 H.P. Diesel Engines—1 new, 1 overhauled.

1—Set Steel Walkway and pipe racks

3,900'—New 3½" 13.30# Nat'l Tube Drill Pipe external upset internal flush—Hughes counterbore weld tool joints

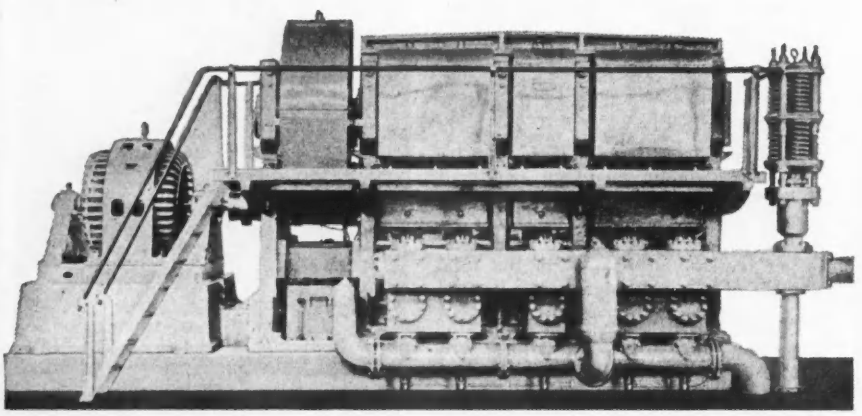
96'—Franks 190000# portable derrick

1—5KW Fieldlite Light plant—Dog houses—Tool boxes and everything to make rig complete—ready to run.

BRIDGEPORT OIL CO., INC.

914 Central Bldg., Wichita 2, Kansas
Phone LD-244

QUINTUPLEX HYDRAULIC PUMPS



5—Hydraulic pumps, vertical, quintuplex, capacity 450 GPM at 128 RPM against 2500 p.s.i. BHP: 685.5, size 4⅝" x 10" mfd. by the Aldrich Pump Co. 1943, ser. nos. 13905-13909 incl., direct connected to

700 HP Synchronous Motors, 3 phase, 60 cycle, 2300 V, 128 RPM, split bearing type mfd. by Electric Machinery Mfg. Co. Complete with motor controls, regulators and switchgear.

HUGO NEU CORPORATION

31 Nassau Street • Telephone: Rector 2-1334 • New York 5, N. Y.

FOR SALE

Used Equipment

2—16¼" x 7¾" x 20" Oil Well Duplex Slush Pumps, excellent condition, $850.00 ea.

1—14" x 7¼" x 18" Wilson-Snyder, same as above, $500.00.

7500'—Range 2, 4½" Fullhole Drill Pipe with 6¼" O.D. Tool Joints, excellent condition, $1.45 per foot.

2—12" x 12" RB Twin Ideal Engines, $750.00 ea.

2—5¼" O.D. x 51' long Octagon Kellys, $750.00 ea.

New Equipment

6—Centrifugal Pumps, 1000 GPM, 281' Head, 1800 RPM, Lombard Governor Corp. Mfr., size and type 4-W.H., $275.00 ea.

2—5" Type E, 800 GPM, 210' Head, 1750 RPM, Gardner Centrifugal Pumps, $225.00 ea.

6—6" Crane 125# Flanged Check Valves, $42.50 ea.

400—18# Chisel Point Crowbars, $1.50 ea.

Atlas Supply Company, P. O. Box 1331, Bakersfield, California.

50—NEW GOULD or LOMBARD centrifugal pumps W/CONTINENTAL RED SEAL 33R engine, 18" impeller, rated 1500 BPH at 288' head. Export boxed w/spare parts & tools. Perfect Condition. $1625.00 each F.O.B. Rockdale.

Also large stock LEROI D-382 power units at $885; LEROI D-176 at $450.00 NEW; Generating units 5, 10 & 25 KW; CRANE & WHEATLEY valves; Hobart welders; Tank Trailers w/pumps; NEW CHRYSLER-HALE fire pumps, BYRON JACKSON PUP, CARTER 4", BARNES 2", All NEW w/engines. Two chemical tandem fire trucks. H. H. COFFIELD, c/o W. H. Orr, Rockdale, Texas.

FOR SALE

2—New 10¾" Ideal Automatic Grip Spiders, each with one set of 10¾" Slips, $1,000.00 each.

3—4¼" x 33' working space new forged steel Baash-Ross Kellys, $500.00 each.

250—Sets new 5-9/16" Hughes fullhole left hand Tool Joints, $1,000.00 for lot. Atlas Supply Company, P.O. Box 1331, Bakersfield, Calif.

FOR SALE

FOR SALE

Roots-Connersville Blowers

15—Size 16" x 18" with 200 HP AC motors

2—Size 20" x 23" with 350 HP AC motors

Hugo Neu Corporation

31 Nassau St., New York 5, N. Y.

It's New... Check It!

PIPE GRINDING MACHINE designed and built to give pipe line contractors maximum service in polishing the bevel on plain end pipe in preparation for welding. The machine can be placed on pipe easily and quickly, and will clean the bevel on 24-inch pipe in 15 seconds, whereas a man with file would have to work at least 15 minutes. The grinder is constructed for durability, light weight, effectiveness and economy. Electrically driven, it may be operated from electric welding machines on the line.

The Machine was perfected, and now being manufactured by

WICHITA TOOL REPAIR CO.
of Wichita Falls, Texas
Under license from O. R. Hall, inventor.

NOTICES, SERVICES

■ Inventor of oil finder offers services of instrument and self. Now located in East Texas. Address: Box 30W, c/o World Oil, Houston, Texas.

Wanted
MACHINES TO BUILD

36 year old firm employing 500, devoted exclusively to the building of Machines, Assemblies and Parts for others wishes to get in contact with companies having complete machines or parts to be made to their design. Estimates furnished promptly upon receipt of prints. Write for list of our machine equipment, visit our plant, or ask to see our representative.

The Hartford
SPECIAL MACHINERY CO.
HARTFORD 5, CONNECTICUT

HELP WANTED

■ Wanted by expanding geophysical company in Alberta, Canada, party chiefs, computers, and observers. Give complete details as to education and experience in first letter. Box 28W, c/o World Oil, Houston, Texas.

PIPELINE SUPERINTENDENT

capable of running big inch spreads. Attractive proposition of salary and profit participation. State experience and references in first letter.

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1221 Baltimore, Kansas City 6, Mo.

Petroleum Engineer

An oilfield service organization has opening for petroleum engineer in technical oil field service. Applicant must have some experience in oil production and degree in petroleum engineering. Permanent position with long established company. Write giving full details on education, experience, age and marital status. Attach small photograph. Address Box 38W, c/o World Oil, Houston, Texas.

WANTED

Petroleum or Chemical Engineers

Degree necessary. Engineering experience not necessary. Single men preferred. Excellent opportunity for training and advancement in Petroleum Reservoir Engineering in all major producing areas. Apply by letter stating education, experience, and marital status to

CORE LABORATORIES, INC.
Box 5810, Dallas, Texas

Here's *why*
CLASSIFIED ADS in the Trading Post Section pay dividends . . .

WORLD OIL is read regularly by men of authority in the drilling, producing and pipe line industry throughout the world.

More men directly and exclusively engaged in the oil producing business are regular subscribers to WORLD OIL than to any other oil paper.

Over 17,000 other men received a copy of the issue you have in your hand, and of these, over 12,000 are men of authority directly engaged in the oil producing business.

The average classified ad in these columns costs about 1/20th of a cent per reader! See Rates at top of page.

Trading Post ads get r-e-s-u-l-t-s

New Books

Pennsylvania Petroleum

"Pennsylvania Petroleum," 1750-1872, is a documentary history compiled and edited by Paul H. Giddens.

Giddens, who is professor of history and political science at Allegheny College, Meadville, Penn., has used the library of the Drake Well Memorial Park, Titusville, as his chief source of information.

The book is a collection of accounts, reports, and letters, many of which have never been published, and many of which are not accessible to the public.

Many old photographs, as well as maps and charts, illustrate the book. Pennsylvania Historical and Museum Commission, Titusville.

Oil Field Development

An enlarged, up-to-date, third edition of "Oil Field Development" by Lester C. Uren is a ready reference work of fundamentals, problems, methods and equipment covering those practices connected with the construction of wells, ready to produce oil. The book discusses in more detail the general factors of developing the field, problems, methods and equipment of drilling, casing, finishing the well, oil-field hydrology, etc., with particular emphasis on improved methods of deep well drilling. Every process and method of consequence is fully explained. Every effort has been made to develop a well balanced treatment of production problems.

Explanations are clear, illustrations are numerous, and the subject is developed in logical sequence. Throughout, the treatment gives a practical understanding of every step in oil field development.

The Gulf Publishing Company, P. O. Box 2608, Houston 1. Price, $7.

WANTED TO BUY

■ Mineral Rod—(or Spanish needles) Four small rods worked by hand. Priming necessary to make instrument work. Some known to be in East Texas. Any information appreciated. Please write J. M. Danner, Folly Beach, South Carolina.

■ WANTED: 3 units MD7 Trackson Pipe Layers mounted on D7 Caterpillar Tractors. Phone or telegraph: International Mercantile Co., 507 Fifth Avenue, New York, Murray Hill 7-3983.

SITUATION WANTED

■ INDUSTRIAL RELATIONS-PERSONNEL ADVISEMENT position desired with reputable concern, preferably in Southwest, but would consider elsewhere. Vast experience in the above with gas, pipeline and telephone companies. Also with large chemical concern and refinery. Familiar with union procedures. College graduate, working on Masters in Psychology. Now employed as psychologist in vocational advisement to veterans. Married. Age 42. Address: Box 42W, c/o World, Oil, Houston, Texas.

LEASES, DRILLING, ACREAGE, ETC.

■ Wanted: Someone to finish test well in Grant County, New Mexico. Will give cash and acreage to party who finishes test to not more than 2000 feet. Hole now at depth of 1040 diameter. Contact Thomas P. McCarthy, P.O. Box 500, Point Pleasant, New Jersey.

WIPE MILES OF TUBING CLEAN!

Code: TUNICATE

WITH A

PATTERSON-BALLAGH TUBING WIPER

Wipes tubing dry. No oil to drip on hoist, rig or tools. Rugged alloy steel housing holds free-floating, self-centering, standard Patterson-Ballagh Special Rubber Wiper.

Housing bolts to flange type heads on bolt centers 9 to 16". Tubing spider is set on top of housing which is constructed to take heaviest tubing loads. Three eye bolts, provided with hammer nuts, lock down lid to hold wiping rubber. Special Rubber Wiper uses same tension principle as Patterson-Ballagh Drill Pipe Wipers. Steel reinforcing ring, molded inside rubber, makes center wiping web flexible, resilient yet firm, durable, and long lasting. Flash-fireproof.

Order complete assembly by code name: TUNICATE. Wiping rubber replacement, code: WINNOW. Send for Catalog No. 180 or see your Supply Store.

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SQUEAKS from the BULLWHEEL

Best Feed for Cows

Cap MacDannald, Houston oil man who had some fine stock exhibited at the Houston Fat Stock Show, was asked by a friend what kind of feed he used to keep his stock looking so sleek and fat.

"Well," he replied, "if you have a lot of walking beams in your pasture you just can't beat that!"

One-Way Street

"Son," said the revenue agent to a little mountain boy, "Can you tell me where your pappy is?"

"He's down the holler makin' whiskey."

"Thanks, and I'll give you a half dollar if you take me down where he is."

"Will you give me the money now?"

"I'll give it to you when we get back. That's fair enough, isn't it?"

"Nope, you ain't gonna be comin' back."

Damming Her Enthusiasm

Cinderella: "Godmother, must I leave the ball at twelve?"

Good Fairy: "You'll not go at all if you don't stop that swearing."

De-Iced

"Your girl is spoiled, isn't she?"

"No, it's the perfume she is using."

By Request

"Who made her dress?"

"I'm not sure, but I think it was the police."

Hints for Householders

"Daddy, I saw Mama kiss the ice man this morning."

"Ye gods! She wastes time on him when we owe the grocer $50!"

Poet's Nook

When Noah sailed the waters blue
He had his troubles same as you.
For 40 days he drove the Ark
Before he found a place to park.

Encore

A damsel who hailed from Madrid
Was naughty in all that she did.
She favored strip poker
And played till it broke her—
Was she a popular kid!

Encore Some More

Mary on a pair of skates
Around the pond did frisk—
Now wasn't that a silly thing,
Her little *

Then the Worm Turned

Junior was a problem child, but the psychiatrist said he should be humored for the time being. When Junior wanted an earthworm to eat, father dug one up. "I want it cooked" was the demand. After it was cooked, Junior ordered, "You eat half and I'll eat half." In the interest of the child's psychological balance the father manfully choked down half the morsel. Junior let out a howl. "I hate you! You ate my half!"

This Curious World

Once there was a girl so popular that a guy tried to buy the beer concession in her apartment.

It takes a lot of experience for a girl to kiss like a beginner.

Did you hear about the girl who went out and got a little rent in her stocking?

Who remembers when a bustle was a stern necessity?

When a wife insists on wearing the pants, it's usually some other woman who wears the fur coat.

The Woman's Way

"My wife is scared to death somebody will steal her clothes."

"Doesn't she have them insured?"

"She has a better idea. She hired a guy to stay in the closet and watch them. I found him there the other night."

No Other Attraction

"What makes you think it was a burglar you saw climbing out of your window?"

"It's bound to have been a burglar. I'm a bachelor."

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EXPERIENCED PRACTICAL CONSULTING REPRESSURING AND WATER FLOODING PRODUCTION ENGINEERING SERVICE

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PETROLEUM ENGINEERS

CABLE & STINE

WICHITA FALLS, TEXAS

10 GOOD REASONS WHY OPERATORS PREFER

McCullough
GUN PERFORATOR SERVICE

1. **MEETS EVERY CONDITION.** Guns fired either electrically or mechanically: guns run on cable, sand line, drill pipe, tubing, or on piano-wire measuring line in extremely high-pressure wells.
2. **SIMULTANEOUS FIRING** under all conditions gives exact spacing of shots, perfect perforation pattern, and saves down-the-hole time.
3. **ACCURATE DEPTH MEASUREMENTS** put the shots right where you order them.
4. **MAXIMUM PENETRATION** of bullets into the formation, as proved repeatedly in competitive field tests.
5. **GUNS TO FIT EVERY CONDITION.** McCullough employs more than 30 different types and sizes of guns.
6. **ALL SIZES OF BULLETS** from $\frac{1}{8}$" dia. up to $\frac{3}{4}$" dia., to fit every possible need.
7. **BURRLESS BULLETS,** giving a completely burr-free hole, eliminating casing scraping, with *no* sacrifice of penetration.
8. **NO LOST TIME.** McCullough's simpler, lighter equipment cuts setting-up and moving-out time, speeds up every job.
9. **EXPERIENCED MEN.** With years of experience behind them, thoroughly-trained McCullough gun-perforating crews do their jobs quickly, efficiently, safely.

These Are Some of the Reasons Behind the Proven Fact That

McCullough

PUTS THE SHOTS WHERE THEY COUNT!

10 This is a section of a McCullough **90-SHOT GUN** perforating a 15-foot section with 6 holes to the foot, at one run.

McCullough TOOL COMPANY

5820 South Alameda St., Los Angeles 11, California
405 McCarty Avenue, (P. O. Box 2575) Houston, Texas

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MISSISSIPPI: Laurel
NEW MEXICO: Hobbs
KANSAS: Ulysses
CALIFORNIA: Los Angeles, Avenal, Bakersfield, Sacramento, Ventura
LOUISIANA: Houma, Lake Charles, New Iberia, Shreveport
WYOMING: Casper

EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y.

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NO-SMOKE
STANDCO BRAKE LINING
Nothing novel—no bunk, but it gets the job done without scoring brake rims. See pages 3973-3978 Composite Catalog.
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COASTAL OIL FINDING COMPANY
Established 1928
ESPERSON BLDG. HOUSTON, TEXAS

THE FORT WORTH LABORATORIES
Analysis of oil field brines, cores, gas, oil and minerals. Field gas testing. Long Distance 138. 823½ Monroe Street, Fort Worth, Texas.

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LD 267—Box 132 Houston, Texas

DID YOU CHECK
The Trading Post?
TURN BACK TO
PAGE 304

SQUEAKS from the BULLWHEEL

Sparring Mates

"The great men are all dead," she said.

"But the beautiful women are not," he replied, earnestly studying her face.

"Of course," she added, "I always except present company."

"So do I."

Short Memory

Mother (entering room unexpectedly): "Well, I never—"

Daughter: "But, Mother, you must have!"

The Better Life

"Two of my daughters are working girls."

"Huh! Two of mine are working men."

Eye-Opener

"Mister, could you spare $100 for a cup of coffee?"

"Since when did a cup of coffee cost $100?"

"I want to get mine in Brazil. I like it fresh."

Hints for Householders

"I don't see how a woman can be happy without a husband."

"Well, call me some night when your husband is away and I'll come over and show you."

The Long View

"Why does Joe look so sad these days?"

"Oh, these long skirts have just about ruined his life. He has no imagination."

Profitable Sermon

The salesman sat in the church, bored and dejected, while the preacher rambled on about the Ten Commandments. Suddenly he reached Number 7 and intoned: "Thou shalt not commit adultery."

The salesman sat upright and snapped his fingers: "Now I know where I left my umbrella."

Turnabout

Boss (to office boy): "What did my wife say when you told her I'd be detained at the office and wouldn't be home till late?"

Office Boy: "She said, 'Can I depend on that?'"

Low Trick

In the dark of night two safebreakers entered a bank. One approached the safe, sat down on the floor, took off his shoes and socks, and started to turn the dial of the safe with his toes.

"What's the matter," said his pal, "let's open this thing and get out of here."

"Naw, it'll only take a minute longer and we'll drive them finger print experts nuts."

Secret Explored

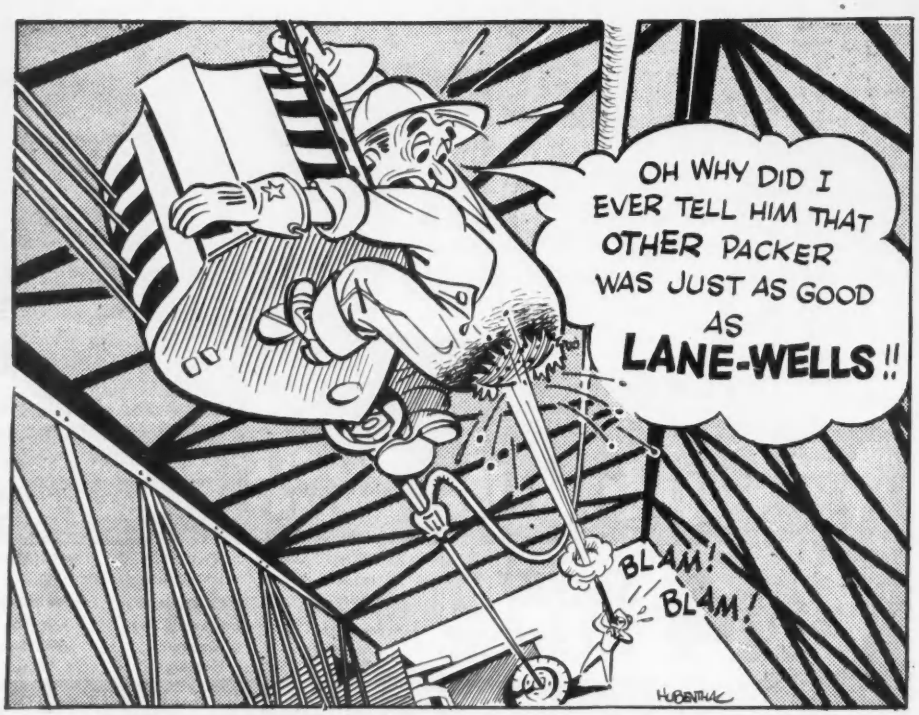
"I didn't know until today that she has a mighty pretty leg."

"Oh, I've felt that all along."

No End to It

"So you want to kiss me! I didn't know you were that kind!"

"Baby, I'm even kinder than that!"



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WORLD OIL

SPECIALIZED FOR DRILLING, PRODUCING,
PIPE LINE OPERATIONS AND MANAGEMENT

APRIL, 1948

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The Cavalcade of Oil

NUMBER FOUR OF A SERIES

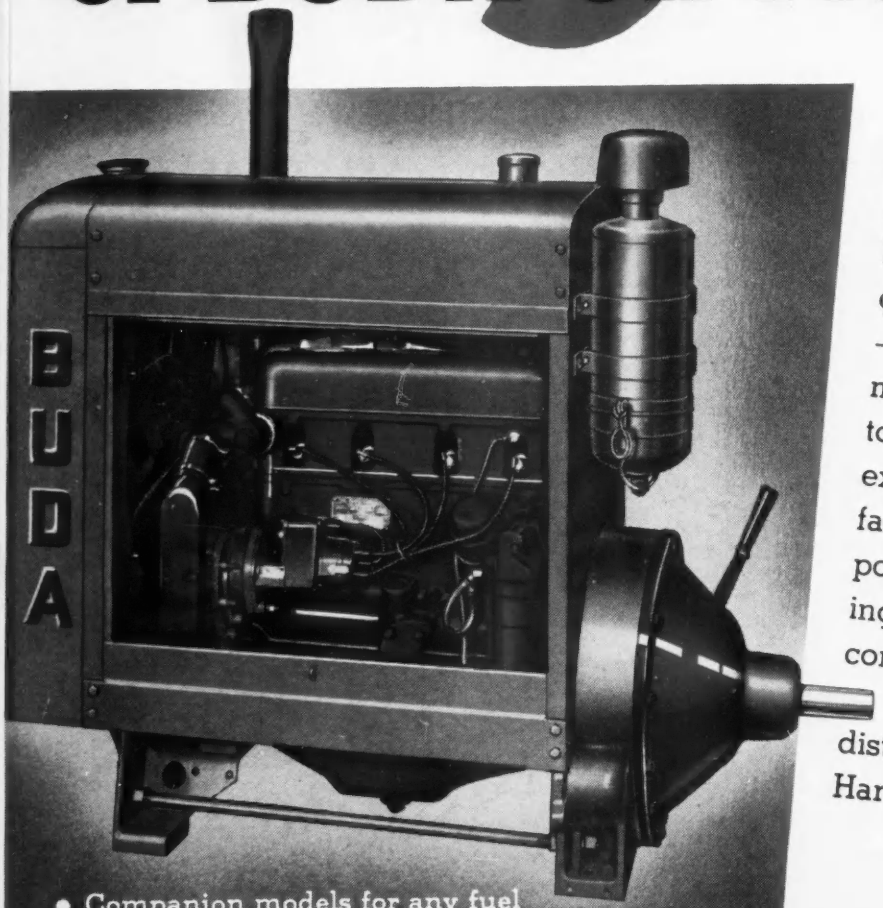
SAMUEL KIER, *father of petroleum refining, was the first to perfect a "purification" process after repeated distilling experiments in his buggy shed and basement laboratories and thus founded the gigantic refining industry we know today.*

Samuel Kier's distilling experiments in his buggy shed laboratory and h thousands of tests with oil lamps in his cellar work shop resulted in the bas "purification" methods of today's gigantic refining industry. Subseque development of Kier's refining process created hundreds of new uses for petroleu and further developed countless oil by-products. The demand for volume produ tion of oil necessitated the introduction of new and more capable drilling equi ment with which to penetrate oil formations of greater depth and resistanc

The invention of the Hughes Rock Bit solved this problem and inaugurat the chain of expanded drilling, volume production of oil, increased refining low-cost automotive fuel, and the economic possibility of mass production automobiles. Constant improvement of Hughes Rock Bits sparked the drilli industry to make petroleum discoveries on all parts of the globe. Since its inventio in 1909, the Hughes Rock Bit has earned and maintained the distinction, "WORL STANDARD OF THE OIL DRILLING INDUSTRY."

HUGHES
TOOL COMPANY
HOUSTON, TEXAS
WORLD STANDARD OF THE INDUSTRY

Announcing 5 NEW MODELS of BUDA Oil Field Engines



- Companion models for any fuel
- Interchangeable parts & mountings
- Precision bearings
- Valve-in-head design
- Removable wet sleeve liners
- Positive force feed lubrication

HERE they are—a brand new "B" and "BD" series of 2, 4 and 6-cylinder Buda engines — adaptable to either gasoline, natural gas, butane, or Diesel — with interchangeable parts and mountings. Rugged, compact and easy to service — precision-built by an experienced oil field engine manufacturer. Proved in the field . . . for powering production pumps, gathering pumps, light plants and other continuous duty oil field applications.

Contact your Buda oil field distributor today. The Buda Company, Harvey (Chicago Suburb), Illinois.

See us at the Oil Show May 15-22, in Tulsa

Model No.	No. of Cylinders	Cu. In. Displ.	Bore & Stroke	Max. Torque Ft. Lbs. @ RPM	Maximum Brake Horsepower at various speeds												
					800 RPM	900 RPM	1000 RPM	1100 RPM	1200 RPM	1400 RPM	1600 RPM	1800 RPM	2000 RPM	2200 RPM	2400 RPM	2600 RPM	3000 RPM
DIESEL																	
2BD-77	2	77	3 7/16 x 4 1/8	49 @ 1400			9	10	11	13	15	16	17				
4BD-153	4	153	3 7/16 x 4 1/8	102 @ 1400			19	21.5	23.5	27.5	31.5	34.5	37	39	40		
6BD-230	6	230	3 7/16 x 4 1/8	156 @ 1400			28.5	32	35.5	41.5	47.5	51.5	55.5	58	60		
GAS-GASOLINE*																	
4B-153	4	153	3 7/16 x 4 1/8	112 @ 1500	15.5	18	20.5	23	25	30	34	37.5	41	44	46	48	
6B-230	6	230	3 7/16 x 4 1/8	164 @ 1000	25	28	32	34.5	37	42.5	48	53	57.5	62	65.5	68.5	72.5

*Available in natural gas and butane

TYPICAL APPLICATONS: To determine actual USABLE h.p. for PRODUCTION PUMPING, take 65% of h.p. shown—for PIPELINE PUMPING, take 70% of h.p. shown. Maximum continuous speed, 1600 r.p.m.

BUDA

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Bulls-eye

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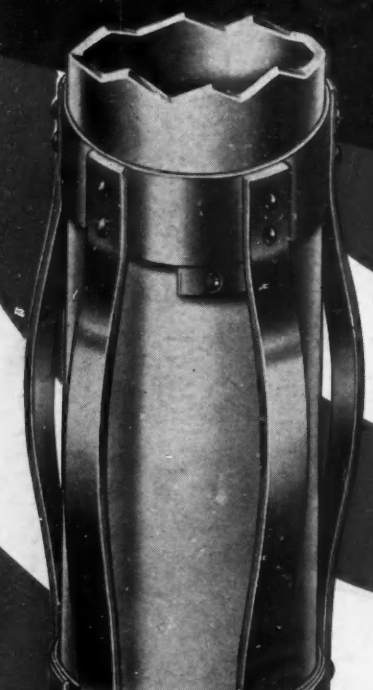

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THAT'S WHY—for centering strength, the Larkin Long Type (Bull's-Eye) Centralizer is constructed with two spring sections in tandem. The shorter arc gives greater strength. There are twice the usual number of arcs—offset to give greater peripheral bearing on the wall of the hole and *from four to twenty times the centering strength of other centralizers.*

THAT'S WHY—to prevent injury to the well bore, the Larkin Long Type Centralizer is equipped with straight rather than helical spring valves. This eliminates the scraping action inherent in the construction of centralizers with helical staves.

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THAT'S WHY—Larkin's Field Representatives, after coming off a complicated cementing job, can report as follows—*"12 of our long centralizers were run to bottom, pulled and later rerun. When they reached the surface they looked like new—well was 8,547' deep."*

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